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# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.*

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

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(Branch of Agricultural & General Engineers, Ltd.)
STEAM ROLLERS. ROAD SCARIFIERS.
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CULVER STREET WORKS, COLCHESTER.
On Admiralty and War Office Lists.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 33 and 59.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
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**Bristol Pneumatic Tools.**
ROCK DRILLS. LTD.
See Advertisement next week.

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See Advertisement last week, page 138.

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MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9983

**Tank Locomotives.**
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7260

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See page 17. 8245

**Petter Oil Engines.**
Manufactured by 3591
PETTERS LIMITED, Engineers, Yeovil.

**"Spencer-Hopwood" Patent Boilers.**
Sole Makers:
W. H SPENCER & CO., HITCHIN, HERTS.
See page 15. 7454

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*BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester.* Od 9753

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SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS. 1894
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**The Scottish Tube Co., Ltd.,**
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 105, Jan. 6.

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SPEEDS UP TO 45 MILES AN HOUR.
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SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.

**Kermodes Limited,**
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NAVAL OUTFITS A SPECIALTY.

**Locomotives Tank Engines** designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 147, last week.

RAILWAY AND TRAMWAY ROLLING STOCK.
**Hurst, Nelson & Co., Ltd.**
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

**The Cambridge and Paul Instrument** COMPANY, LIMITED. 8194
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GENERAL CONSTRUCTIONAL ENGINEERS,
**Boilers, Tanks, & Mooring Buoys**
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

**Tubes and Fittings.**
**Stewarts and Lloyds, Ltd.,**
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See Advertisement page 130. 8187

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AERIAL ROPEWAYS, CABLEWAYS, CRANES.

**Steel Castings.** 8161
See displayed advertisement every alternate week.
JOHN M. HENDERSON & CO., ABERDEEN.

**The Glasgow Railway Engineering Company,** GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 8357

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**Augustin-Normand**
67, rue de Perrey—LE HAVRE (France). 3890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

**Rubber** MANUFACTURERS.
Conveyor Belts
GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 7535

**Electric Cranes.** 8143
S. H. HEYWOOD & CO., LTD., REDDISH.

**R. Y. Pickering & Co., Ltd.,** (ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices: WISHAW, near GLASGOW.
London Office: 3, VICTORIA STREET, WESTMINSTER, S.W. 8353

**Diesel Driven Generators,** 400-500 Kw., D.C., 500 or 250 Volts, 350 R.P.M., in excellent condition. Low price. Engines and Dynamos could be sold separately.
Also TWO 500 Kw. Parsons TURBINES, 220 Volts, D.C., complete with Spare Armature and Condenser.
Exhaust TURBINE SET, Williams-E.C.C., 200 Kw., 440/500 Volts. Complete with Condenser, Pumps, &c. JENNINGS,
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**Royles Limited,** ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents
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High-class GUNMETAL STEAM FITTINGS
WATER SOFTENING and FILTERING. 8726

**Yarrow Patent Water-tube Boilers.** 7768
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

**Matthew Paul & Co., Ltd.** Dumbarton. 7689
LEVENFORD WORKS.
See Full Page Advt., page 74, Feb. 6.

**Forgings.**
**Walter Somers & Co., Ltd.,** HALESOWEN. 7110

**"Delta" Brand** HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 8131
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

**Taylor & Challen Presses.** 8198
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Feb. 6.

**Railway Switches and Crossings.**
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 1903

**P. & W. MacLellan, Limited,** CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 128, Trongate, GLASGOW. Od 8847
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**Machine and Engineering** WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROBSON & RUSSELL, LTD., Queen's Wharf, Hammersmith, NEW PATENT AUT.—ROBSON & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

**Locomotive Traversers** (ELECTRIC). 8143
S. H. HEYWOOD & CO., LTD., REDDISH.

**Dredging Plant** OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
**Werf Conrad,** HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., Friars House, 39-41, New Broad St., LONDON, E.C. 2.
*See half-page Advert. last week and next week.* 7526

**Centrifugals.**
**Pott, Cassels & Williamson,**
MOTHERWELL, SCOTLAND. 7849
See half-page Advertisement page 86, Jan. 23.

## The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

## The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the Interests of Foremen on their Supervisory Capacity. C 508

All communications to— R. W. RHID, General Secretary. Head Offices— 81, High Holborn London, W.C.1.

TO RETIRED NAVAL OFFICERS.

## An Association has been

formed to safeguard the interests of all Commissioned Officers who have served in the Royal Navy and Royal Marines, as well as their widows and children. For particulars, write to Sec., A.R.N.O., 8, Victoria Street, S.W. 1.
General Meeting, R.U.S.I., 2.30 p.m., 20th February, 1920. D 559

THE

## University of Liverpool.

SESSION 1919-20.
FACULTY OF ENGINEERING.
DEAN—Associate Professor J. WEMYSS ANDERSON, M.Eng., M.Inst.C.E., M.I.Mech.E.
Prospectuses and full particulars of the following may be obtained on application to the Registrar: Engineering, Electrical Engineering, Civil Engineering, Naval Architecture, Marine Engineering, Design and Drawing, Refrigeration, Mathematics, Physics, Chemistry, Geology. D 479

## Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of ENGINEERING.

## Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (HONS.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 88, South John Street, Liverpool.

## Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8394

## Engineering Special Classes.

Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 354, Oxford Rd., Manchester.


## TENDERS.

INDIA OFFICE, WHITEHALL.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

## Tenders from such persons as may be willing to SUPPLY

ROAD BRIDGES, 40 ft., 50 ft. and 60 ft. clear span.

The Conditions of Contract may be obtained on application to the DIRECTOR-GENERAL OF STORES, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 17th February, after which time no Tender will be received.

J. STEVENS,
Acting Director-General of Stores.
6th February, 1920. D 597

THE GREAT CENTRAL RAILWAY COMPANY are prepared to receive

## Offers for the Removal of the

OLD BRIDGE which formerly carried the Great Central Railway over the River Trent at Keadby, Lincolnshire. The material to be removed consists approximately of 380 tons of wrought-iron girder work, 300 tons of cast-iron work in cylinders, and some 50,000 cubic feet of timber work, and the small ironwork in connection therewith in dolphins and river staging.

Drawings can be seen and particulars obtained on application at the office of the Chief Engineer of the Great Central Railway, Marylebone Station, London, N.W. 1., on and after Monday the 9th instant.

Offers, on the prescribed form, to be sent in sealed envelopes so as to reach Mr. Jas. CAMPBELL, Secretary, Great Central Railway, Marylebone Station, London, N.W. 1, on or before Thursday, 4th March next. D 485

LONDON COUNTY COUNCIL.

The COUNCIL invites

## Tenders for the Supply of

two "GUNBOAT" TYPE STEEL BOILERS with furnace fittings, smoke boxes, uptakes, etc., for one of the Woolwich Ferry Boats. The Specifications, bills of quantities, form of tender, drawings, etc., may be obtained on application to the Chief Engineer at the County Hall, Spring Gardens, S.W., upon payment, to the Cashier of the Council, of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a bona fide tender, and shall not have withdrawn the same. Particulars may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the County Hall before the payment of the fee.

Tenders must be upon the official forms, and no Tender received at the County Hall after 4 p.m. on Monday, 8th March, 1920, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
D 524

BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

## Tenders for the Supply of :—

(a) 73 tons Spring Steel.
(b) 114 tons Steel Material.
(c) 707,500 Dog Spikes.

For each copy of the Specifications (a) a fee of 10s. will be charged, and for (b) and (c) a fee of 20s. each will be charged, which fees are not returnable. Tenders enclosed in sealed envelopes addressed to the "CHAIRMAN & DIRECTORS," and endorsed "Tender for Spring Steel," "Steel Material," or "Dog Spikes," as the case may be, must be delivered at the Company's Offices not later than Twelve noon on Friday, 20th February, 1920. The Directors do not bind themselves to accept any or the lowest Tenders and reserve the right to divide the orders.

51 tons of the Spring Steel and 65 tons of the Steel Material are urgently required in Burma.

By Order of the Board,
W. HOME,
Managing Director.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
12th February, 1920. D 509

COUNTY BOROUGH OF SALFORD.

ELECTRICITY DEPARTMENT.

The Electricity Committee invite

## Tenders for the Supply,

DELIVERY, and ERECTION of TWO WATER TUBE BOILERS, having an evaporation of not less than 45,000 lbs. per hour, together with stokers, mechanical draught plant, etc.

Specifications and all particulars may be obtained on application to the Borough Electrical Engineer, Frederick Road, Salford. Tenders duly endorsed and addressed to the "Chairman of the Electricity Committee" must be delivered at the offices in Frederick Road, Salford, not later than Monday, the 23rd inst.

L. C. EVANS,
Town Clerk.
D 549

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

## Tenders for the Supply of

LOCOMOTIVE DUPLICATE PARTS.

Specifications and forms of Tender may be obtained at the Company's Offices, Finsbury Pavement House, E.C. 2.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Locomotive Duplicate Parts," must be left with the undersigned not later than 2 p.m. on Tuesday, the 24th February, 1920.

A charge, which will not be returned, will be made of 20s. for each copy of the Specification. Copies of the drawings may be obtained at the office of ROBERT WHITE, Esq., M. Inst. C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W.

By Order,
W. B. REYNOLDS,
For Managing Director.
Finsbury Pavement House,
E.C. 2. D 533

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

## For Sale by Public Tender.

PLANT AND MACHINERY.

Tenders to be received not later than 10 a.m., FEBRUARY 26th.

STEAM WINCH.

By Sykes, Lot No. 78, two cylinders, on channelled irons and sleepers. Vertical Boiler, 10 ft. by 4 ft., with four-wheeled trolley, 5000 ft. 6 m/m coil steel rope.

Lying at the KITH BALLOON SCHOOL, LYDD. Ref. G. 1986, M.K. 22023.

EDGE RUNNER MILLS.

Grinding Mills and Runners, Mortar & Pestle, of Wedgewood, as No. 5 on their catalogue.

Lying at the ROYAL GUNPOWDER FACTORY (Lower Stores) WALTHAM ABBEY. Ref. G. 1676 M.K. 17639/33.

BOOT MACHINERY.

Sewing Machines with C.I. Stands. Ref. M.K. 18323/7.

Regent Sheers Power Presses. Ref. M.K. 18320/18322.

Boot Stamping Machines. Ref. M.K. 21543/4 (16 altogether).

Lying at the R.A.C.D., PIMLICO. Ref. G. 1558.

DISINFECTING MACHINE.

Petrol-driven, by Clayton & Co., Tyne M., complete with two lengths of Armoured hose, each 15 ft. long with couplings. The gas from this machine is effective within 20 minutes. Ref. G. 1977 M.K. 21908.

Lying at the BARRACKS, OSWESTRY S.D.

SILICOL PLANT AND TANK.

Admiralty Type B, for the production of Hydrogen Gas, constructed by Messrs. S. Cutler & Sons, to produce 10,000 cu. ft. per hour. Overall dimensions 30 ft. by 11 ft. by 20 ft., comprising soda tank and tray, Generating Chamber, Water Storage Tank, Scrubber and separator. 1½ hp. Motor for driving the stirring gear, complete with starter, piping, valves, staying, etc.

Overall dimensions of tank staying, etc., built of 9 in. by 4 in. timber. Ref. G. 1859 M.K. 21497.

Lying at the BALLOON STATION, SHEERNESS, KENT.

Fuller particulars of the above, together with Tender Forms and permits to view, can be had on application to the CONTROLLER, D.B.I.o., Charing Cross Embankment Buildings, W.C. 2.

NOTE.—For particulars of other Government property for sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. D 390

CITY OF BELFAST.

ELECTRICITY DEPARTMENT.

The Corporation invite

## Tenders for the Manufacture,

DELIVERY and ERECTION, at the New Harbour Power Station, Belfast, of a

COAL HANDLING PLANT,
UNDER SECTION "K."

The specifications and other particulars may be obtained on application either to Messrs. Preece, Cardew & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, or to Mr. T. W. BLOXAM, M.I.E.E., City Electrical Engineer, Belfast.

Tenders, upon the presented forms, must be lodged in the Town Clerk's Office, City Hall, Belfast, not later than Monday, 22nd March, 1920.

The lowest or any Tender will not necessarily be accepted.

An official receipt must be obtained for every tender delivered by hand. Tenders sent by post must be registered.

R. MEYER,
Town Clerk. D 602

PORT OF BRISTOL.

GRAIN BARGES.

The Docks Committee are prepared to receive

## Tenders for the Construction

of THREE GRAIN BARGES, each about 100 ft. long, 25 ft. beam and 10 ft. deep. TENDERS ARE INVITED FOR THE BARGES BUILT IN STEEL AND, ALTERNATIVELY, IN FERRO-CONCRETE.

On and after Friday, the 13th day of February, 1920, a copy of the Form of Tender, General Conditions, Specification and a copy of the Contract Drawings can be obtained from the undersigned, on production of a receipt showing that a deposit of £5 has been paid to the General Manager and Secretary of the Docks Committee, Dock Office, 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned to all *bona fide* tenderers.

The Tenders must be enclosed in a sealed envelope, endorsed "Tender for Grain Barges" and addressed to the General Manager and Secretary of the Bristol Docks Committee, Dock Office, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Friday, the 5th day of March, 1920.

THOMAS A. PEACE,
Engineer.
Engineer's Office,
Avonmouth Docks,
10th February, 1920. D 591

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

## For Sale by Public Tender :—

CONTRACTORS' PLANT,
LYING AT
NEW MECHANICAL TRANSPORT DEPOT, SLOUGH,
Comprising the following :—

2 ton Loco. Cranes, by Both D. Bell.
5 ton Loco. Cranes, by Smith & (Grafton).
3 ton Loco. Cranes with Grab, standard gauge.
Whittaker Navvy 2 yd. Bucket.
2 and 5 ton Hand Crabs.
Petrol Engines, Engines and Pumps of different sizes and makes.
Loco. Engine, 2 ft. gauge.
Petrol Tractor, 2 ft. gauge (Dorman & Stafford).
Pumps by Tangye, Evans Pulsometer and others.
Winget Concrete Block Making Machines with Pallets, etc.
Winget Mixer, 3 cu. ft., complete with 2½ HP. Petrol Engines.
Side Tip Wagons, standard gauge.
Bin Yards, 20 lbs., 2 ft. gauge.
Refuse Destructors.

Tenders close Ten a.m., February 28th.
Ref. G. 1320.

Full particulars of the above, together with Tender Forms and Permits to View, can be obtained on application to the CONTROLLER, D.B.I.o., Charing Cross Embankment Buildings, W.C. 2.

NOTE.—For particulars of other Government Property for Sale, see *SURPLUS*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. D 428

## APPOINTMENTS OPEN.


## A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of ENGINEERING.


HERIOT-WATT COLLEGE, EDINBURGH.

## Instructor Required in the

subjects of ELEMENTARY MATHEMATICS, APPLIED MECHANICS and ENGINEERING DRAWING, to take Classes for demobilised apprentices. Temporary appointment at the rate of £300 per annum.

Applications, with full particulars, to be lodged with the PRINCIPAL of the COLLEGE not later than the morning of TUESDAY, 17TH FEBRUARY. D 513

WORCESTER EDUCATION COMMITTEE.

VICTORIA INSTITUTE SCIENCE and TECHNICAL SCHOOL.
Headmaster.—J. NEWTON FRIEND, D.Sc.

## Applications are Invited for

the POST of ASSISTANT ENGINEERING INSTRUCTOR. Initial salary £280 per annum with prospects of increase. Further particulars may be obtained from the HEADMASTER. Applications should reach me not later than February 25th.

THOS. DUCKWORTH,
Secretary for Higher Education.
Victoria Institute,
Worcester. D 572

STAFFORDSHIRE EDUCATION COMMITTEE.

## Applications are Invited for

the POST of HEAD of the ENGINEERING DEPARTMENT, County Technical College, Wednesbury, at a salary of £500.

Further particulars and forms of application, which must be returned before MARCH 3RD, may be obtained from the undersigned.

GRAHAM BALFOUR,
Director of Education.
County Education Offices,
Stafford,
February, 1920. D 335

ROYAL TECHNICAL INSTITUTE, SALFORD.
Principal - B. PRENTICE, D.Sc., Ph.D.

HEAD OF MECHANICAL ENGINEERING DEPARTMENT.

## Applications are Invited for

the above APPOINTMENT. Candidates should possess a University degree or its equivalent, and have had workshop experience. Previous teaching experience and laboratory practice essential. Salary scale, £450 to £650. The commencing salary will be fixed according to qualifications and experience. Further particulars and forms of application may be obtained from the SECRETARY, Education Office, Chapel Street, Salford. Last day for applications, Saturday, March 6th.

L. C. EVANS,
Town Clerk.
D 467

ROYAL NAVY.

## Applications are Invited

for APPOINTMENTS as INSTRUCTOR-LIEUTENANTS in the Royal Navy.

Candidates must be under 30 years of age, have had a University Training and have taken an Honours Degree in Mathematics, Science or Engineering; they should also have had some teaching experience.

The rates of pay are from £365 per annum on entry to a maximum of £949 per annum as Instructor-Commander. Promotion by selection, to Instructor-Captain is also open, with a maximum of £1 277 per annum.

Retired pay, to Officers over 40 years of age, after 12 years' service, ranges from £300 per annum for an Instructor-Lieutenant to a maximum of £999 for an Instructor-Captain, according to length of service. Service pension is also allowed to Officers if invalided before becoming eligible for retired pay.

For further particulars apply in the first instance to

THE SECRETARY OF THE ADMIRALTY,
Whitehall, S.W. 1. D 459

LONDON COUNTY COUNCIL.

## There is a Vacancy at the

L.C.C. School of Engineering and Navigation, High Street, Poplar, E., for a WHOLE-TIME TEACHER OF ELECTRICAL ENGINEERING AND PHYSICS, for the Day Technical School and Evening Classes. Experience in practical engineering, laboratory work, and class teaching is desirable. The candidate selected will be required to take up his duties after Easter, 1920. Commencing salary £225 to £315 a year, according to qualifications and experience, rising to £330 by yearly increments of £15, thence by £10 increments to £440 a year.

Preference will be given to candidates who have served or attempted to serve with His Majesty's Forces.

Application forms may be obtained from the EDUCATION OFFICER (T. 1), Education Offices, Victoria Embankment, W.C. 2. (Stamped addressed foolscap envelope necessary.)

Forms must be returned by 11 a.m. on 23rd February, 1920. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
D 525

BOLTON EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL SCHOOL.

## Applications are Invited for

the POST of ASSISTANT LECTURER in the Engineering Department.

Candidates will be required to take day and evening classes in Mechanical Engineering, including Laboratory Work. They should possess a university degree or its equivalent, and have had workshop experience. Previous teaching experience and laboratory practice essential.

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Further particulars and forms of application may be obtained from the undersigned, and must be returned not later than February 28th, 1920.

F. WILKINSON,
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Education Offices,
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Bolton. D 544

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RUTHERFORD TECHNICAL COLLEGE.

PRINCIPAL:—MR. C. L. ECLAIR-HEATH, Wh. Sc., A.M.I.M.E.

## Applications are Invited for

the undermentioned LECTURESHIPS :—
(a) Mathematics and Physics.
(b) Engineering Subjects.

Candidates should have the following qualifications :—

In the case of (a) A University or Technical College education with a University degree or its equivalent, practical experience in the work of a Physics Laboratory and teaching experience.

In the case of (b) Good training in a Technical College or equivalent Institution in Theoretical and Laboratory work of Engineering Science, a Diploma or Certificate of Proficiency, and experience in Engineering Works and of teaching.

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THOS. WALLING,
Acting Director of Education.
Education Offices,
Northumberland Road. D 402

# THE VIBRATION OF SPARS IN AIRCRAFT.

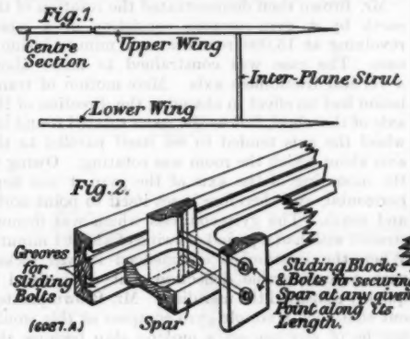
By A. H. STUART.

THE following investigation was commenced with the view of determining the cause of the vibrations which were found to exist in the lower plane of an aeroplane at high engine speeds. The position of the interplane struts was found to play so important a part, however, that this part of the subject was investigated in considerable detail.

Fig. 1 shows the disposition of the wing spars and strut of the machine in question. The strut made contact with the rear spar of the lower plane at a point one-third of the spar's length from the free end. This fact suggested that the trouble was the result of the natural vibration of the spar, the strut being placed at the node of the harmonic of the third order.

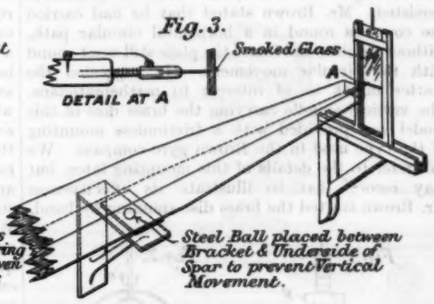
The machine was supported with its flying axis vertical, and a needle inserted in the free end of the spar. The spar was then set in vibration while a smoked glass plate was moved in a vertical plane across the needle point, at a known speed by means of a clockwork device. In this way the frequency of the spar's vibration was determined. The experiment showed beyond doubt that the natural vibration of the spar synchronised with the revolutions of the engine at the speed at which the trouble was experienced. Except for the diminishing amplitude the curve recorded on the smoked glass was an almost perfect sine curve. The strut was moved outwards a few inches and the experiment repeated. The character of the curve obtained was entirely changed, a very marked harmonical character being introduced. Moreover, for a given initial amplitude, the vibration died out very much more rapidly than was the case when the sine curve was recorded.

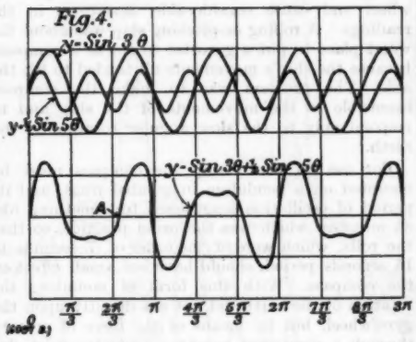
In order to investigate in detail the influence of the strut position on the vibrations of a spar, a spar was secured to the wall by the means shown in Figs. 2 and 3. The end of the spar which was attached to the fuselage, was rigidly held between blocks secured by long bolts. Fig. 2 shows how the strut position was reproduced. By slackening the nuts of the bolts these blocks could be placed in any required position. At the free end of the spar a needle was fixed (for detail see A in Fig. 3), which pressed lightly against a smoked glass plate which could be raised between grooves by means of clockwork not shown in the figure. The spar rode lightly on steel balls, carried between two brass plates, at two points in its length. These prevented motion in a vertical plane and corresponded to the compression ribs in a built-up wing.

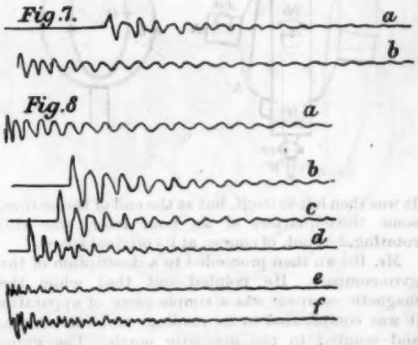


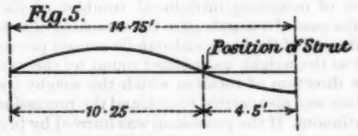


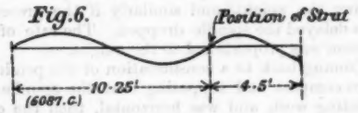





The experimental spar was 14·75 ft. long, and for the strut to be at the node of the harmonic of the third order, it must be placed $\frac{14 \cdot 75}{3} = 4 \cdot 92$ ft. from the free end. In the machine mentioned above the amount which it was possible to move the strut was limited not only by considerations of stress, but also by the fact that too great a movement would introduce the same trouble into the upper plane. A movement which would place the strut midway between the nodes of the upper and lower planes would give a corresponding movement of 5 in. on the experimental spar, that is, to a position 4·5 ft. from the free end.

The clamp was placed in this position and a record obtained on the smoked glass plate (which was subsequently immersed in weak varnish and reproduced photographically). The record is shown at *a* in Fig. 7. The clamp was now moved to the nodal position, viz., 4·92 ft. from the free end, and another record obtained which is shown at *b* in Fig. 7.

Now the latter graph is a fairly pure sine curve (with a diminishing amplitude of course), whereas the former curve *a* obviously contains the harmonic of the fifth order at least.

Analysis gives the equation:

$$y = \sin 3\theta + \tfrac{1}{2} \sin 5\theta.$$

The graph of this equation has been plotted, and is shown in Fig. 4. For the purpose of comparing it with the photographic record the graph should be regarded as commencing at A. The two terms of the equation seem to indicate that the vibration is the resultant of the natural vibrations of the portion of the spar between the fixed end and the strut, and the portion from the strut to the free end. The period of these vibrations will obviously be different, and the form of vibration to be expected is that shown in Fig. 5. This, however, does not support the equation obtained by analysis. Fig. 6 shows an alternative form of vibration.

In this case the wave-length ($\lambda_1$) of the longer portion is 10·25 ft. and that ($\lambda_2$) of the extension is $\frac{4}{3} \times 4 \cdot 5 = 6$ ft. The ratio $\frac{\lambda_1}{\lambda_2} = \frac{10 \cdot 25}{6 \cdot 0} = 1 \cdot 71$, whereas the ratio indicated by the equation is $\frac{5}{3} = 1 \cdot 67$. The agreement between the two is as close as can be expected, when it is remembered that the experimental spar is not of uniform section.

Now if the strut is so placed on a spar as to avoid the node of any low harmonic, the spar is compelled to vibrate (if it vibrate at all) in the manner described above. This has two advantages:—

1. The natural vibrations of the spar are less likely to synchronise with the revolutions of the engine.

2. The vibrations, when set up, will die out much more quickly than they will if the whole spar is vibrating with the same period.

In order to have some indication of the effects of moving the strut more and more from the nodal position of the harmonic of the third order, a number of records were taken, and are shown in Fig. 8. *a* was taken with the strut at the node (*i.e.*, 4·92 ft. from the free end). The strut was then moved outwards with intervals of 4 in., hence the records *b*, *c*, *d*, *e*, and *f*, were obtained with the strut 4 in., 8 in., 12 in., 16 in. and 20 in. outside the node respectively. It will be observed that higher and higher harmonics are introduced into these graphs as the strut is moved outwards. It has not been thought worth while to apply harmonic analysis to these graphs.

Fig. 9 shows a similar set of traces, of which *a* was taken with the strut at the node, and the remainder with the strut moved successively 4 in. inwards (*i.e.*, towards the fixed end). It will be observed that these graphs are practically pure sine curves, and it seems likely that the bulk of the vibration is due to the movement of the extension only, the portion between the fixed end and the strut becoming more and more nearly rigid. If this is so the wave-lengths of the graphs should vary directly as the lengths of the extensions, since the wave-length of the fundamental vibration of the extension will be four times its length. The following table gives the measured values, and fully justifies this hypothesis.

| — | Wave-length of Graph. | Wave-length of Extension Vibration. | Wave-length Reduced to Common Unit. | |
|---|---|---|---|---|
| | | | Graph. | Extension. |
| | in. | ft. | | |
| *a* | 0·307 | 19·68 | 1·00 | 1·00 |
| *b* | 0·315 | 21·0 | 1·03 | 1·07 |
| *c* | 0·337 | 22·32 | 1·10 | 1·13 |
| *d* | 0·370 | 23·68 | 1·20 | 1·20 |
| *e* | 0·392 | 25·0 | 1·28 | 1·27 |
| *f* | 0·408 | 26·32 | 1·33 | 1·34 |

Of course, where a machine has only one pair of interplane struts, questions of stress give a very small range of choice of position for the strut, but these experiments seem to point to the wisdom of avoiding any position more remote from the free end than 30·5 per cent. of the whole length.

## THE GYROSTATIC COMPASS.

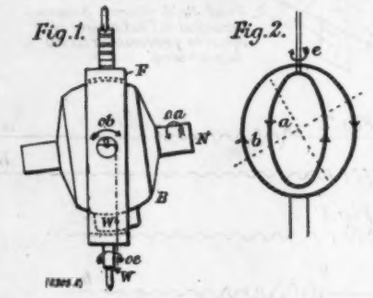
Although it is to be trusted that engineers in general have a rough working idea of the mode of operation of the gyro-compass, it is probable that to a more general public the apparatus is merely some kind of refinement on the magnetic compass. That this is so was illustrated by an incident related by Mr. Sidney G. Brown at a meeting of the Royal Institution, on the 30th ult. Mr. Brown stated that after his recent lecture on the subject during the meetings of the British Association at Bournemouth, a member of the audience asked him how he shielded his compass from outside magnetic influence. That such a question should be possible from a more or less selected audience like that of the British Association suggests that even a rudimentary knowledge of the gyro-compass is not very widespread. The Royal Institution meeting to which Mr. Brown told this story was assembled to hear a further lecture from him on "The Gyrostatic Compass," and it was made abundantly clear from the outset that the gyro-compass had no other connection with the magnetic compass than that the two instruments were used for the same purpose.

Mr. Brown began with a brief consideration of some features of the magnetic, or mariner's, compass which rendered an alternative to it desirable. In the first place, as was well known, the magnetic poles of the earth were not coincident with its geographical poles, and, furthermore, were continually varying in position. In London, in 1657, the magnetic needle pointed true north, while in 1800 there was an extreme westerly variation of 24½ deg. Since then it had been slowly coming back to its present position, 14½ deg. west of true north. The angle of deviation varied in different parts of the globe, and magnetic charts had to be worked to. A further point in connection with the mariner's compass was that the earth's field which furnished the directing force for the compass needle was not very strong. On a wooden ship the accuracy of a good modern magnetic compass left little to be desired, but on an iron ship there were difficulties. The earth's field tended to be weakened in the fore and aft direction of an iron ship, while across the ship the field was stronger. As it was essential that the magnetism in which the needle lay should be uniform in direction in whatever direction the ship might happen to lie, the stronger fore and aft field had to be reduced by magnetic shielding. This naturally reduced the directive force and tended to make the compass sluggish in action. The difficulty was particularly acute in the case of a battleship, while in the interior of a submarine a magnetic compass could not be used at all.

It was quite possible on an iron ship to correct the errors of the compass, but as the ship herself might be a magnet and one of variable strength, it was important that the reading of the compass should be tested at every opportunity. A ship's magnetism might change through the hammering action of the waves, or through the heating action of the sun on one side of the vessel, or through a leak to earth on any of the electric wires that might be running near the compass. The swing of a modern compass was damped by immersing the needles and card in a liquid such as alcohol, but as the fluid was attached to the ship and turned with it, the swinging of the ship in any direction carried the liquid round and reacted on the needle and card, so that the compass had a tendency to be carried round with the vessel. This lag in the instrument rendered it difficult to hold a ship dead on her course, and the path, as a consequence, was sinuous and might oscillate, even in a calm sea, as much as 7 deg. on each side of the correct heading. As a ship had usually to steer entirely by the reading of the compass, any error was serious.

It was in 1861 that Evan and Smith first discovered how important it was to mount the needles of a magnetic compass on the card so that the moments of inertia of the moving system should be the same about all directions, that was to say that the system should be in dynamic balance. If this condition was not complied with the rolling of the ship caused deviations in the reading. Mr. Brown stated that he had lately discovered that another deviation could be brought about, not by an oscillation in one direction, but by the card being set wobbling. The needle and card would then have a force applied trying to carry the moving system round in the direction of the wobble. Mr. Brown demonstrated this form of deviation by a model consisting of a heavy brass disc some few inches in diameter, mounted on a vertical frictionless spindle. Magnetic needles were fixed to the disc and the whole system was carried on a pendulous mounting, as in the gyro-compass. The disc and needles were in correct static and dynamic balance.

By swinging the pendulum of this model in any direction, Mr. Brown showed that no deviation was caused. By causing it to swing in a circular conical path, thus giving a wobble to the plate, a serious deviation was at once produced. This error was permanently maintained against the earth's attraction so long as the circular motion of the pendulum persisted. Mr. Brown stated that he had carried the compass round in a horizontal circular path, without wobble, and found the plate still went round with the circular movement. He suggested the matter might be of interest to mathematicians. The vertical spindle carrying the brass disc of this model was provided with a frictionless mounting of the type used in the Brown gyro-compass. We will refer to the details of this mounting later, but may record that to illustrate its effectiveness Mr. Brown started the brass disc spinning by hand,




It was then left to itself, but at the end of the lecture, some three-quarters of an hour later, was still rotating, but not, of course, at its original speed.

Mr. Brown then proceeded to a description of the gyro-compass. He pointed out that while the magnetic compass was a simple piece of apparatus it was complicated in its readings and corrections, and pointed to the magnetic north. The gyro-compass, on the other hand, was a complicated instrument, but was simple in its reading and pointed to the true north. He then defined a simple gyrostat as an accurately-balanced spinning wheel mounted with as little friction as possible, and in such a way that the axis of the wheel might point in any direction in space. He illustrated some of its simple properties from a model, and showed that translation in space did not alter the direction of the axis, but that it was acted on by any force which tended to give the axis a new direction in space. The matter can be illustrated from Fig. 1, annexed, in which is shown a gyro-wheel in a casing as used in the Brown gyro-compass. The wheel is supposed to be spinning in the direction *o a*. If a force is impressed on the wheel tending to tilt or rotate it round another axis *o b*, then the wheel will "precess" or move in such a direction as to try to make the two axes *o a* and *o b* coincide, and the direction of spin of the wheel coincide with the new direction of rotation that was attempting to be produced by the applied force.

This property of a gyrostat had, the lecturer stated, an electrical analogy. Thus a circuit, consisting of an outer fixed coil and a central suspended coil, shown in Fig. 2, had similar mathematical laws to that of the gyrostat. A strong direct current indicated by *a* was kept flowing in the centre coil. This corresponded to the spin of the wheel. If a direct current indicated by *b* was sent round the outer coil, then the centre coil would move in such a direction as to make the axes of the magnetic fields of the two coils coincide, and to make the directions of the two currents also coincide. The coils, in fact, would move, or try to move, in such a way as to make the self-induction of the whole circuit a maximum. This was very much like the gyrostat, or, in fact, any piece of mechanism, which, under impressed forces, tended to move so as to make the whole moment of inertia a maximum. If the gyrostat had its axis fixed parallel to the earth's surface, but free to turn in azimuth upon a frictionless vertical spindle, the earth would act upon the instrument, and it would be a gyro-compass. The earth as it rotated continually tilted the axis of the wheel in space, the wheel therefore would turn so as to set its axis of rotation as nearly as possible parallel to the axis of the earth. It was only when the two axes coincided that the wheel was free from any further tilting action. That is, when the axis of the wheel was pointing true north.

Mr. Brown then demonstrated the rotation of the earth by a gyro-compass consisting of a wheel revolving at 15,000 revolutions a minute inside a case. The case was constrained to move about a vertical frictionless axis. Mere motion of translation had no effect in changing the direction of the axis of the wheel, but as the room rotated round the wheel the axis tended to set itself parallel to the axis about which the room was rotating. Owing to the mounting of the axis of the gyro it was kept horizontal, and therefore it set itself to point north and south. The gyro-compass which was demonstrated with had a period of swing of about 1 minute. When the instrument commenced it was locked with a considerable deflection, but when freed it quickly indicated the meridian. Mr. Brown pointed out that such a simple gyro-compass as this would not be of any use on a moving ship because the rolling would react too violently on the spinning wheel and cause considerable deviations in the readings. A rolling or pitching ship was about the worst place to put a gyrostat to act as a compass, because the ship's movements all tended to tilt the axis. The problem was to make the compass insensible to the movements of the ship and to respond only to the slow angular rotation of the earth.

For use on board ship the compass must be mounted on a pendulum in gymbal rings, and its period of oscillation lengthened to something like 85 minutes, which was the usual practice, so that the rolls, which were of the order of 7 seconds to 15 seconds period, should have but small effect on the compass. With this form of mounting the rotation of the earth did not act directly upon the gyro-wheel, but by means of the force of gravity through a pendulous weight. Unfortunately this form of mounting introduced troubles of its own. In the case of a simple gyro the attaching of a weight to the end of the horizonal spindle caused precession, but as the weight was carried round by the gyro the new direction of rotation which the weight tried to induce was also carried round, and the precession was continuous. If the precession was hurried by pressing horizontally on the spindle end the spindle tilted, lifting the weight, and similarly if the precession was delayed the spindle dropped. The rate of precession was proportional to the weight.

Coming back to a consideration of the pendulous gyro-compass and supposing that the spindle was pointing west, and was horizontal, then the earth as it rotated would leave the wheel pointing in that one direction in space. The weight, however, would try to follow the earth's rotation, and would start precessing the gyro towards the north, the rate depending on the weight. All the time the wheel was coming to the north the earth would be adding to the rate of precession, and the spindle would as a consequence be tilted, and at the north position the weight would be deflected. Under these conditions the effect of the weight would be to continue the precession, and the gyro-wheel would swing through the north position and continue to move until the effect of the earth arrested and reversed the motion. The compass would consequently continue to swing through the north position with constant amplitude, backwards and forwards, undamped. To render the compass of use some method of damping had accordingly to be introduced so that the compass might finally settle on the north.

The damping of a gyro-compass could be carried out by friction—preferably fluid friction—between the vertical spindle and its support, but although

this method would damp the swing it was inadmissible because the movements of the ship would react through the friction and cause errors of reading. Anschutz, in his early form of compass, by use of an air blast got rid of this connection with the ship. The air blast was arranged to oppose the movement in azimuth when the wheel tilted, and thus he obtained an effective method of damping. The strength of the air blast, which varied proportionately to the tilt, should be nothing when the compass was at rest on the north, that is, when the tilt was nothing. This would be true with the compass on the equator. In other latitudes, however, the compass rested at the north with a tilt still remaining. It did not come back to the horizontal position because the axis of the wheel was trying to set itself parallel to that of the earth. This left a residual air blast continually acting, producing a permanent twist in azimuth and a constant error. It was therefore preferable to damp the swings of the compass by acting on the tilt rather than its movement in azimuth, because in that case there would be no latitude error.

The tilt was at a maximum at the middle of each swing—that was when the gyro was moving through the north position—and it was the return of the weight to its truly vertical position that was responsible for the continuation of the oscillation. What was required, therefore, was some method of neutralising the action of the weight, not before, but after the compass had reached the north. This was accomplished in the Brown gyro-compass by automatically moving a liquid from one bottle to another, and in such a direction as to counterbalance the weight and precess the gyro wheel. The action was delayed by means of a valve, or constriction, in the tube joining the two bottles.

The force with which the compass sought the north was proporticnal to the product of the rotation (1 revolution in 24 hours) and the spin of the wheel. The faster we could spin the wheel the more did we obtain directive force. It was for this reason that the wheel was rotated at the maximum speed consistent with strength and rise of temperature. In the Brown gyro-compass the wheel was 4 in. in diameter and 4½ lb. weight. It ran at 15,000 r.p.m. The maximum directive force of the earth on the wheel, when the spindle was pointing east to west, was only the weight of 30 grains at a leverage of 1 in. This small force continually diminished in value as the axis approached the north direction and vanished absolutely in that direction. If the compass were deflected, say, 1 deg. from the north then the force of restoration was only ¼ grain at a leverage of 1 in. This showed how important it was to eliminate as completely as possible any friction on the vertical axis which would tend to oppose the directive action of the earth.

There were three forms of gyro-compass in use, the Anschutz (German), the Sperry (American) and the Brown (British). In the Anschutz the vertical axis was supported by a bath of mercury; in the Sperry, by a suspended wire, of which the twist, if any, was taken out by a follow-up motor through an electric contact which switched on the current to the motor; and in the Brown by a hydraulic system of support. In this latter arrangement the lower end of the vertical spindle acted as a ram and stood upon a column of oil. The oil was kept under a pressure of about 500 lb. per square inch, and was continually being kept pumped up and down, thus raising and lowering the vertical axis some 180 times a minute. This continually moving arrangement gave a practically frictionless support, so that the total moving part which weighed about 7½ lb., could be carried round in azimuth by the smallest force due to the earth rotation. The compass, if deflected, would always come back to its true north position, certainly within $\frac{1}{10}$th degree.

It was mentioned earlier that the period of oscillation of the gyro-compass was about 85 minutes. The reason for this had reference to what was known as the north steaming error. The earth had no angular movement from south to north, but had one from west to east due to its revolution of its axis. A ship, however, sailing to the north, at, say, 20 knots, introduced an angular movement in that direction, because it was moving over the curved surface of the ocean, and would complete a revolution of the globe in 45 days. If there were a gyro-compass on the ship it would be sensible of these angular movements and would set itself so as to make a compromise between them. It would point not true north but one or more degrees west of the actual pole. This diversion was termed the north steaming error. Knowing the latitude, the speed of the ship and its direction north and south, the extent of the error could be accurately calculated, and correction tables had been prepared so that the error could be determined and allowed for for any latitude, speed and heading. Automatic means had also been devised to make the corrections. For instance, the repeater used with the Brown compass was arranged so that the card could be set eccentric, so that when once set the corrections were applied automatically without further reference to the tables.

If a ship was in harbour, then a gyro-compass on board would be pointing true north, but when the ship started steaming to the north the compass would begin an oscillation so as to bring the axis of the wheel into the new resting position to include the north steaming error. Getting up speed would, however, have another effect on the compass. The gyro wheel was acted on by a pendulous weight. As the ship changed its speed the acceleration would

*Fig. 3.*

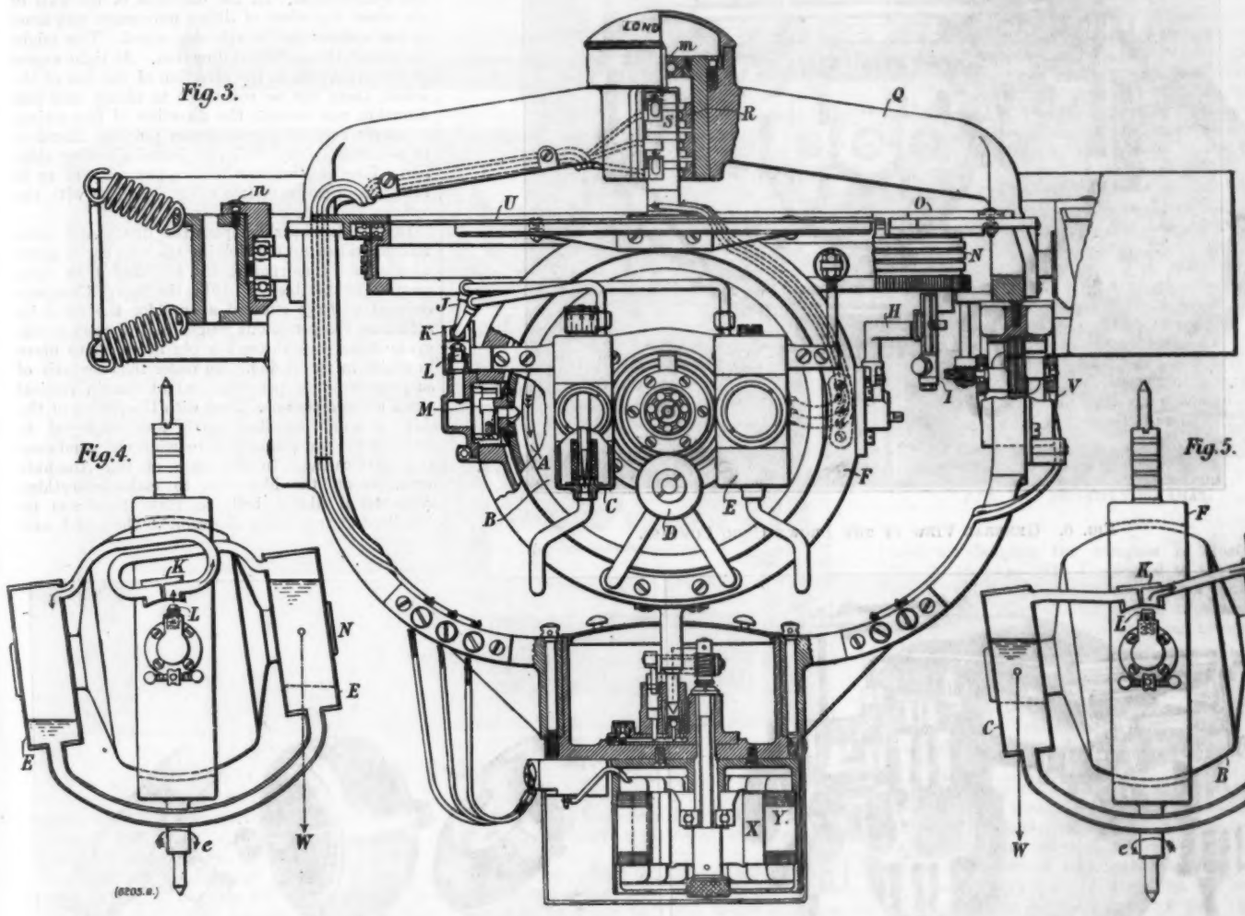
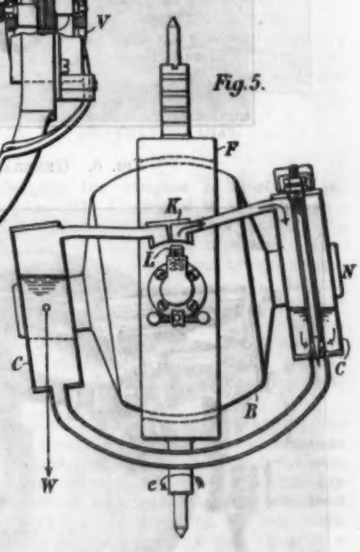



*Fig. 4.*




*Fig. 5.*



act on the pendulous weight and cause an oscillation to be started. This oscillation was termed the ballistic deflection. The permanent north steaming error and the transitory error due to the ballistic deflection were in the same direction and mathematicians had calculated that with an undamped gyro-compass, with a time of oscillation of 85 minutes, the ballistic deflection could be made exactly the same as the deflection due to the north of little moment, but on a war vessel which was manœuvring it might be serious, and might swing the compass off its correct reading by several degrees. Mr. Brown stated that he had made modifications in his compass to remove the damping error, but would not explain them as they had not been tested in practice.

There was a further error, the existence of which was not known when the gyro-compass was first quadrantal error. The extent of the error depended upon the violence of the ship's rolling and the direction of the axis of the wheel. If the compass pointed N., S., E. or W., the error was nothing, and was a maximum in the intermediate positions before mentioned.

Mr. Brown went on to say he thought Anschutz was the first to point out the quadrantal error and suggest a cure. In 1911, speaking of the tendency of the compass to wander when on board ship, Anschutz said "Theoretically the influence of rhythmic turning movements on a gyroscopic apparatus must disappear completely, if not only the real, but also the apparent moments of inertia of the movable system become equal for each plane." A consideration of the simple gyro-compass would show that the movable system is not symmetrical. In the direction of the axis of the wheel the effect of tilting movement was more or less resisted by the spinning wheel. This might be termed the stabilised direction. At right angles to this, that was in the direction of the rim of the wheel, there was no resistance to tilting and this direction was termed the direction of free swing. A simple form of gyro-compass pointing therefore in a direction, say, N.W. on board a rolling ship, had a force applied to it tending to turn it so as to bring its direction of free swing into line with the roll.

In the Anschutz compass the quadrantal error was got rid of by multiplying the number of gyro-wheels and constructing the instrument as symmetrical as possible. In 1914, the Sperry Company claimed to have effected a cure for the error by attaching the pendulous weight, not directly to the gyro casing, but through a pin arranged to move in a slot in the casing. In order that the axis of suspension of the pendulum might remain vertical when the compass oscillated with the rolling of the ship, a small auxiliary gyro was employed to stabilise the pin connection between the pendulum and gyro-casing. In the case of the Anschutz arrangement, the idea was to make everything symmetrical like a ball, so that there was no stabilised or free swing direction to the wheel, and

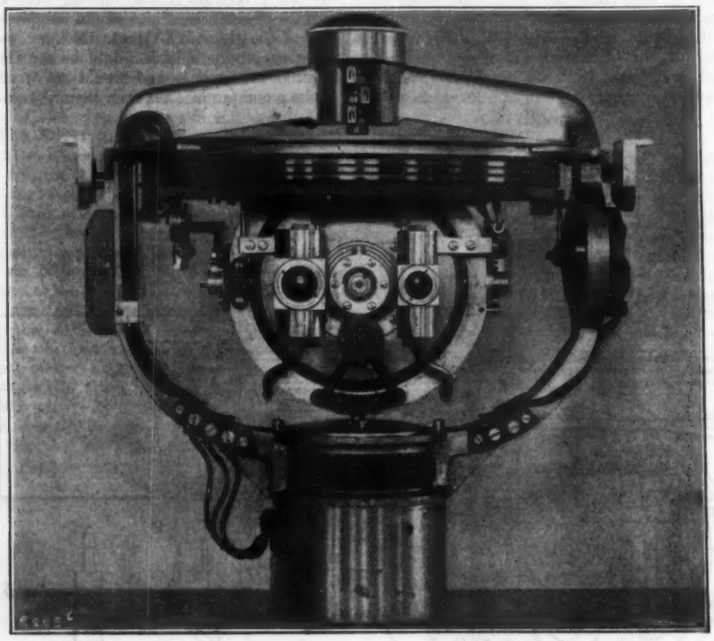


Fig. 6. General View of the Brown Gyro Compass.

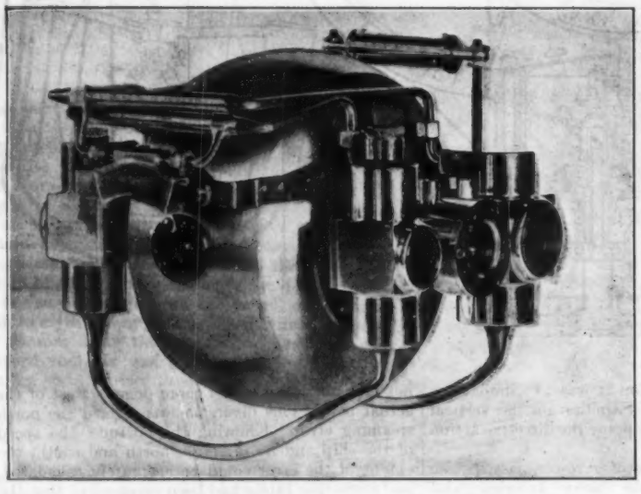


Fig. 7. View showing Arrangement of Oil Bottles.

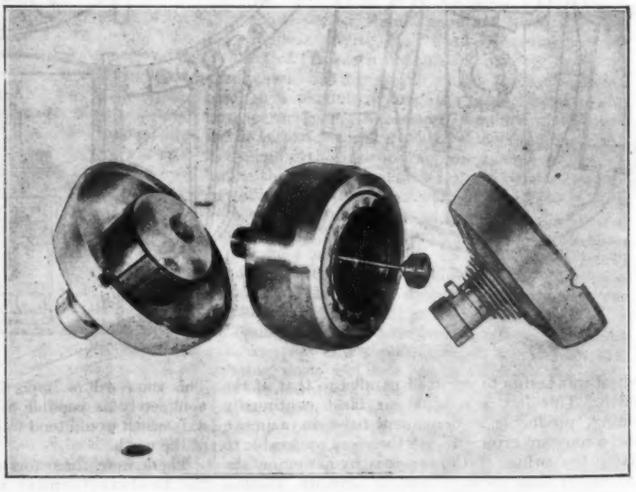


Fig. 8. Gyro Wheel and Casing.

steaming error. This being so the compass should move into its new resting place without further oscillation.

The calculation for an undamped compass did not, however, apply to the damped gyro-compasses of practice, and the ballistic deflection had to include a term due to the damping. This term had in the past been neglected, but in practice it had been found that when a ship was steaming and turning to alter her course the compass did not come dead-beat to its new position, but had an oscillation started which was common to all gyro-compasses. The extent of this oscillation might be termed the damping error. On a merchant ship this error was brought out. It had proved a most difficult fault to correct and its elimination had had more to do with the design of the later forms of gyro-compass than any other factor. If a gyro-wheel was precessed towards, and kept pointing to the north by an ordinary pendulum weight it would work well on board ship provided that the ship was steaming on a fairly smooth sea. If, however, the compass pointed anywhere in the quadrants, that was N.W. or N.E., S.W. or S.E., and the ship rolled, the wheel would try to set itself so as to bring the rim of the spinning wheel in line with the roll. In a long-continued and heavy roll the compass might show an error of 20 or more degrees. This was called the therefore no tendency to turn. In the Sperry arrangement a method was provided to prevent the point of application of the pendulum weight from moving and acting as a crank, and, by keeping the pendulum weight always vertical in the N.W. direction, to destroy its power of turning the compass.

In the Brown, the quadrantal error was eliminated by making the weight operate completely out of phase with the roll, at 90 deg. displacement. If a gyro-compass was worked by a weight which tended to precess the wheel in phase with the roll, then there must be a quadrantal error. There would be no error, however, if it was forced to operate

completely out of phase with it. It was also essential that the real movements of inertia should be the same in all directions of the movable system of the compass. That was to say the moving system should be in dynamic balance. If a child's hoop was suspended by a string and was swinging in one direction, the hoop tended to set itself lengthwise to the direction of the swing. On the other hand, if an exactly similar hoop was placed over, but at right angles to, the first, then on swinging the hoops there would be no tendency for them to turn, as they would be in dynamic balance. It was for this reason that the mass distribution of the moving system of the gyro-compass should be in dynamic balance, and to carry this out adjustable

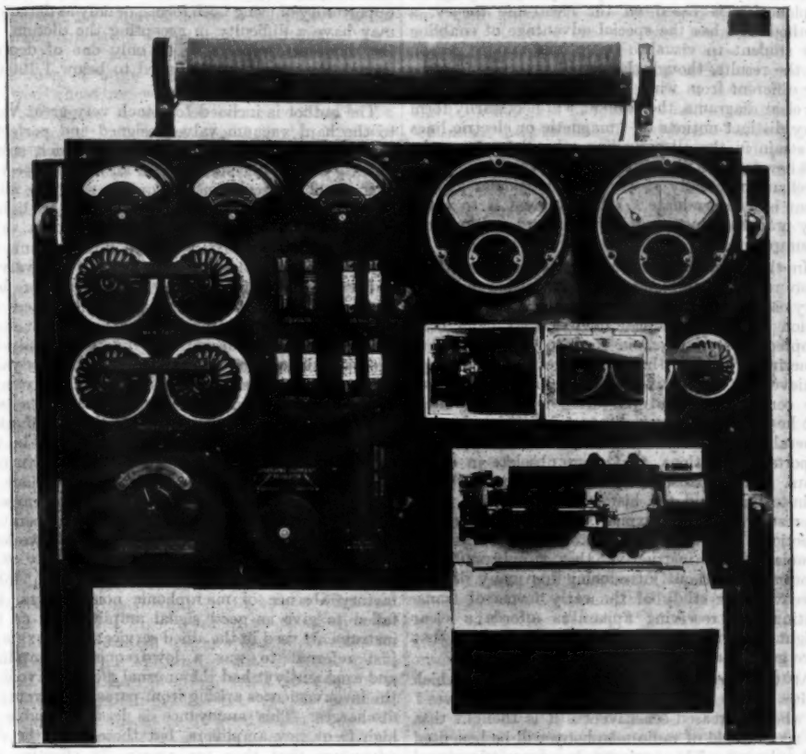


FIG. 9. SWITCHBOARD.

weights were fitted, usually in the direction of the spindle of the wheel, to counteract the weight of the supporting ring in the gyro casing.

The Brown gyro-compass is shown partly in section in Fig. 3, on page 203 (a perspective view is also given in Fig. 6). A is the gyro wheel in its casing B. This casing is carried on knife-edges M in the vertical ring F, and is thus free to tilt under the action of the rotation of the earth. The vertical ring turns in azimuth on a frictionless mounting consisting of an oil pump at the bottom and a ball bearing *m* at the top. X Y is a three-phase motor which drives the oil pump. The gyro wheel is the rotor of a three-phase motor, and current is led into the moving system through the three sets of iron contact rings R and S. These rings do not touch, but the outer sets are hollow and mercury fills the spaces between them and the inner rings, so that there is little friction. The vertical ring is dynamically balanced by two projecting weights D. The part marked Q is the pendulous mounting supported by gymbal rings and by the outer rows of springs to take up shock.

The gyro wheel runs at 15,000 r.p.m., and thus acts as a powerful blower, giving an air pressure equal to some 3 in. of water. Fixed to the vertical ring, but connected through the hollow bearing M to the inside of the case is the air jet L. This jet blows into the two halves of the air-box K and thence through the pipes J. The air pressure is thus transmitted to the oil in the two sets of bottles C and E. Another air jet at H is similarly mounted and employed to act upon a pair of contact-making vanes I. The contacts I, through the agency of the controller, which is fixed on the switch-board, works the repeaters and the step-by-step motor V. This motor forces the follow-up ring N to keep the contact-making vanes I always opposite the air jet. The result of this action is that all the repeaters in the ship follow suit. The compass card is shown at U, fixed to the upper portion of the vertical ring. The lubber line support is at O. By removing the four screws marked *n*, the gyro-compass can be completely removed from the gymbal rings. The instrument so removed is shown in Fig. 7, on page 204. (A perspective view of the gyro wheel and casing is also shown in Fig. 8.)

The action of the oil bottles can be explained by reference to Figs. 4 and 5, on page 203. Reference may first be made to Fig. 1, which illustrates the simplest form of compass in which the wheel and case B are controlled by the pendulous weight W. When the case is tilted, as shown in the figure, W is moved to one side of the vertical support, and the weight tries to bring the case again to the horizontal. If the wheel revolved in the direction of the arrow *o a*, the righting torque would be in the direction of the arrow *o b*, and the wheel and case would turn in azimuth in the direction of the arrow *o c*. Such a compass would have a quadrantal error because the weight would produce stresses in phase with the roll. Fig. 4, on page 203, illustrates the method of control of the Brown compass. When the case is horizontal, the bottles E E are each half full of oil, and the air jet L blows equally into the two halves of the air-box K. When, however, the case is tilted, as shown, then the air pressure blows into one side of the box more than into the other, and in such direction as to force the oil from the lower bottle into the one that is raised. There is, therefore, a considerable righting torque exerted by the weight of the oil in trying to restore the case back again to the horizontal.

When the pendulum swings under the action of the rolls of the ship the air jet L moves from one side to the other of the air-box in time with the roll, blowing the oil periodically from one bottle to the other. At the middle of the swing of the pendulum the air jet is at the middle of the air-box, and there is no difference of air pressure, and consequently no movement of the oil. When the swing is at the end of its path and not moving, the air jet is at one side of the air-box and producing the maximum movement in the oil. It will therefore be seen that the movement of the pendulum and the movement of the oil are out of phase with each other. It is for this reason that, given good dynamic balance, there is no quadrantal error whatever with this method of control. The system

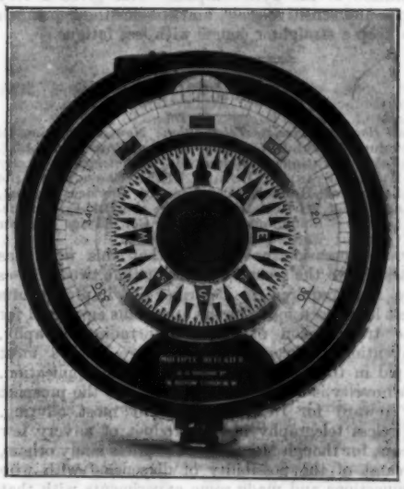


FIG. 10. MULTIPLYING DIAL.

used for damping the compass is illustrated in Fig. 5, on page 203. Connected to the same air-box K, which operates on the two oil bottles E E, is a second pair of damping bottles C C. The arrangement is much the same as before, except that the air acts in the opposite direction. In one of the bottles, as shown, there is an adjustable needle valve which regulates a constructed passage. By means of it the flow of oil from one bottle to the other can be suitably retarded. (The general arrangement of the four oil bottles is well shown in Fig. 7.)

Referring to the accuracy of his instrument, Mr. Brown stated that in the case of a Brown compass on board a flagship in the North Sea during the war, which was observed with particular care, especially in heavy weather, it was reported that the instrument was never more than 1½ deg. from the true north position during the whole of the tests. Trials on a commercial ship had demonstrated that the employment of a gyro-compass resulted in the ship steaming every day over 3 per cent. greater mileage. That was to say one day's steaming in 30 would be saved with, of course, proportionate saving in coal and other expenses.

At the conclusion of his address, Mr. Brown referred to the application of the gyro-compass as a gun director. The use of the gyrostat in the Whitehead torpedo had revolutionised naval strategy, and he believed the use of the same instrument in the form of a gyro-compass gun director might possibly produce profound changes in gunnery practice in the future. In modern naval warfare the guns had to be worked and fired while the distant targets were invisible to the gunners. The guns had to be directed by observers in an elevated position, and these observers communicated the distance of the target and its direction in space. This direction in space might be supplied by a gyro-compass, and once the guns were properly trained they could be joined up to, and controlled by, the gyro-compass The turrets would act as huge repeaters, and the compass would hold the guns on the distant target

quite independent of the movements of the ship, which might be steaming at full speed or manœuvring. The final matter to which Mr. Brown referred, was the pioneer work of Anschutz. He thought great credit was due to the courage displayed in the first attempts to utilise the feeble force resulting from the earth's rotation to operate a compass. The majority of the illustrations accompanying this article, have been referred to in the course of our *resumé* of Mr. Brown's address. We should, however, say here that Fig. 9 shows the controlling switchboard through which the repeating dials are operated and from which the motors which form part of the gyro-compass itself are started and stopped. Fig. 10 illustrates a multiple repeater, in which the outer dial rotates four times for one rotation of the gyro-compass. This gives a very open and sensitive scale, and enables the helmsman to keep a straighter course with less fatigue.

## LITERATURE.

*Text Book on Wireless Telegraphy.* New edition, in two volumes. Vol. I. *General Theory and Practice.* Vol. II. *Valves, Continuous Waves and Radiotelephony.* By Rupert Stanley, B.A., M.I.E.E., Chevalier of the Legion of Honour. Professor of Physics, Belfast, and Chief Wireless Instructor in the B.E.F., France. London: Longmans, Green and Co. [Price 15*s.* per volume.]

It will occasion no surprise that this work has passed into the second edition, or that two volumes are now required to describe the improvements that have been made in the apparatus employed for the transmission of signals by radio-telegraphy. Invention is keenest and advance always most rapid in the early days of commercial application, for novelty is then most attractive and the prospect of reward for fresh development most alluring. Wireless telegraphy is the product of a very few years, for though Morse, and doubtless many others, dreamt of the possibility of dispensing with wire connections and made some experiments with that end, its practical success was not assured till Hertz demonstrated the importance of high-frequency oscillations, and Marconi showed how electromagnetic waves could be utilised in the transmission of signals and detected by a sufficiently sensitive apparatus. Technical applications have been many and ingenious since those days; capital has been provided lavishly as success grew more certain, and, most important of all, scientific research has been sedulous and eager, as the prospect of ameliorating the conditions of human life became fully revealed. To many in civil life, the outbreak of war seemed to oppose the regular progress of investigation, and the sudden disappearance of all aerials on August 4, 1914, was a distinct and visible sign of the arresting influence the impending disaster seemed destined to wield in so many directions. But there were compensations; the war had the effect of concentrating the attention of many able minds on problems ripe for development; research flowed in new channels that facilitated mechanical progress. Nimbleness of thought and quickness of design were stimulated and achievement had to follow rapidly on suggestion. Tests, too, were severe and practical when usage was rough, and experience was so quickly gained that Professor Stanley, who spent four years exclusively on specialised wireless work, tells us that radio-telegraphy was completely revolutionised by the improvements introduced under the stress of war. This greater intensity reacted on ordinary development as shown by the rapidity with which wireless telephonic records were broken. Before the war the longest recorded range for telephony was 1,000 km., and reliable commercial range barely exceeded 100 miles. On September 28, 1915, wireless telephony was established across the American Continent from Arlington to Hawaii, a distance of 5,000 miles, and a month later from Arlington to the Eiffel Tower, Paris. How these results, among others, were accomplished is the fascinating tale that Professor Stanley has to tell, and it is one that should hold the attention. He counts himself fortunate in holding an appointment which brought him into intimate contact with the new development, and now that the time has come when it is permitted to disclose freely the results attained and used by the military staff, we are hardly less fortunate in having the record from one so closely connected with the work.

But if the adaptation of apparatus by ourselves and allies for the purposes of war adds life and novelty to the treatise, this is accidental. Professor Stanley's main object is to instruct a student class. His purpose is to teach, and to show that the successive steps which have had a successful result were not fortuitous, but the consequences of a satisfactory theory. For this reason he describes the effects and processes that make wireless telegraphy possible, giving an adequate explanation of the phenomena produced, or at least one sufficiently exact to be apprehended by those whose acquaintance with mathematics or physics may be limited. The fundamental principle underlying the explanation is based on the electronic theory, a method that has the special advantage of enabling the student to visualise operations and to reason on the results, though the actual processes may be far different from what we imagine. Accompanied by clear diagrams, the student will necessarily form very distinct notions of "magnetic or electric lines of strain in the all-pervading ether," for example, but how far such diagrams represent the complicated mechanism actually at work in a particular experiment is indeterminate. If the student is to make any practical progress, it is necessary to make some assumptions.

In the description of apparatus, however, there is no room for ambiguity, and the author explains very satisfactorily both the principles and the action of the mechanical devices that have been adopted to secure certain results. It is necessary sometimes to show how these results have been achieved by alternative methods, and to point out the conveniences and the disadvantages of each, but he has been more desirous to keep in view the general principles involved than to instance unimportant variations, that grow obsolete in a few years. The expansion of the science has followed definite lines, and the history will not only prove interesting but will explain the reasons for this direction. The author's historical remarks are stimulating and instructive, they supply sufficient information without introducing too many details. Moreover, the study of the early forms of transmitting and receiving apparatus affords a clear insight into the more complicated artifices that have grown out of simpler devices.

At the present moment, the apparatus which excites the greatest curiosity are forms of "valves" by whose increased sensitiveness it is thought that the special field of radio telephony will be benefited and enlarged. This curiosity has been stimulated by the secrecy the authorities have maintained, and the exhibition of an apparent unwillingness to allow the public to participate in the advantages accruing from the investigations that have been diligently pursued, both in the laboratory and in the field during the war. To the development of the valve and related apparatus, together with the method of use, the author has devoted one entire volume, in which he presents much information that has been acquired in his official position. The practical remarks founded on actual experience will be much appreciated.

The generic principle of the valve is no new discovery. This form of detector and oscillator has been in the hands of experimenters for some years and has proved itself the fruitful parent of various devices, which figure under the names of the "Audion," the "Pliotron," and many others, which are to be recommended on different grounds. The Fleming valve from which all of these have been derived has a "soft" vacuum, and in its simplest form consisted of a small electric lamp, with a single hairpin filament, surrounded by a sheet of copper attached to a third terminal on the lamp. It utilised the unilateral conductivity effects of an electron discharge from a heated filament to a plate at a higher potential than the filament, and was prized not for its increased sensitiveness, for in that respect it was inferior to a good crystal combination, but on account of its robustness, remaining unimpaired by strong signals and atmospherics. The distinctive improvements that have been effected since consist, first, in the introduction of an auxiliary electrode, between the filament and the plate, of a "grid" or mesh of metal wire, through which the electrons can pass easily when the potential of the grid is made positive compared with the filament. The second alteration is in the character of the vacuum. For some years after the thermionic valve came into use, it was believed that electron emission could not take place unless there was some gas surrounding the heated filament, but in 1914 Dr. Langmuir proved that the electron current was stronger and more uniform when the vacuum was "hard" or, as perfect as possible. The author contends that the advent and development of this form of vacuum valve has revolutionised the practice of radio signalling. The author's experience no doubt justifies this assertion, though those who have not had the opportunity of using both forms, or only as detectors, may have a difficulty in accepting the dictum, for the difference appears to be only one of degree; though the pressure be reduced to below 1/100,000 mm. of mercury.

The author is inclined to attach very great value to the hard vacuum valve designed and perfected by the French military authorities, which subsequently became the standard for all wireless receiver and amplifier circuits in the equipment of the allied armies, and his wide experience cannot be lightly set aside. The circumstances under which a valve is used have always to be taken into account, for it is very clear that there may be no "best valve" under all conditions. The valve that is best adapted for rectification may be ill suited for amplification, or generation. In the present stage of experiment, the design that functions admirably for transmission may be ineffective for heterodyning continuous wave signals. An interesting example is given by Professor Stanley in the case of a two-valve amplifier constructed by the Telefunken Company and captured from the Germans in the campaign. It was very ingeniously constructed, the distinguishing feature being the use made of the increased resistance of iron wire with temperature to keep the filament current and temperature constant, with the view of ensuring steady working of the valves on batteries whose voltage may vary. The mechanism functioned perfectly with satisfactory absence of microphonic noise effects, but failed to give as good signal amplification as the instruments used in the allied service. The example just referred to was a low-frequency amplifier, and apparently it had the unusual merit of avoiding the inconveniences arising from parasitic currents or discharges. This annoyance is less noticeable in high frequency amplifiers, but these have the disadvantage that they are practically effective for only one given frequency, the sensitiveness falling sharply above and below this frequency. Professor Stanley expresses the opinion that the design of a short wave high-frequency amplifier has not yet been successfully achieved, though here inquiry is stimulated by the hopeful prospect of eliminating jamming by local signals. Such remarks, and we might quote many more, show that much experimental work has yet to be accomplished before it is possible to speak with decision upon the best form of valve.

The author's method of tracing the variations in particular designs, giving sufficient instances to illustrate the principles involved is admirably adapted for exhibiting the lines along which progress has been made, and is calculated to compel the attention of the class of students for whom he is writing. His description of the methods and principles of heterodyne reception of undamped waves is clear and pertinent, and like the whole subject of continuous-wave transmission is admirably treated. The prospect of employing shorter aerials and of reducing the inconveniences of jamming will lead to much experimenting with this method in the near future, and tend to bring about a corresponding extension of radiotelephony. For the hope of substituting direct speech for the signals of a Morse code, in communicating with a distant station, is distinctly stimulating. But there are many difficulties yet to be overcome before a sustained conversation can be carried on. For example, in order to receive an answer to a question it is necessary to pass from transmission to reception,

and this is by no means so easy of accomplishment as in ordinary line telephony. There are methods of "breaking in," but these require special appliances and their manipulation is not sufficiently easy for public use. Doubtless the perfected machinery and the practical method that will generally be adopted will differ very materially from those which have been used in experiments, but at present the connection of telephone wires to a radio-transmitter seems to offer a practical solution. A telephone subscriber might speak from his office through the line wire to the radio transmitter, whence an expert operator could connect him with the lines on the other side of the space, to be bridged by radio telephony. Professor Stanley considers that long-range telephony will be developed with high-frequency alternators, but considerable transmitting energy will be required as radio telephony ranges are short compared with those of continuous-wave telegraphy. If valve transmitters were employed a number of large valves in parallel would be required whose renewal would be very costly. In this connection it may be remarked that when radio communication between Arlington and the Eiffel Tower was successfully achieved, as a *tour de force*, some 300 or 400 valves were required in parallel to give the necessary power, apart from the banks of multiplying valves and of control valves between the microphone and the power units. It is both easy and unprofitable to speculate on what may be the outcome of future experiment. The valve in its Protean forms has proved an instrument of marvellous sensibility for detecting electro-waves, and another revolutionary invention may set at nought our most reasonable prophecies. To do the author justice, he indulges in no sensational predictions. His object has been to instruct, and his book should be useful both to those who are intelligently interested in the scope of radio transmission, as well as to those, who, unable to follow strict mathematical deductions, need expert technical guidance to gain the necessary familiarity with mechanical expedients and elementary principles.

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*Printing for Business: A Manual of Printing Practice in Non-Technical Idiom.* By JOSEPH THORP, Printing Consultant to W. H. Smith and Son. London: John Hogg. [Price 7*s.* 6*d.* net.]

THE writer of this manual is to be congratulated, for he found his life's work in an occupation for which he was suited, and working with sincerity has acquitted himself with credit. "I was pitchforked by fate into printing, and I have learnt to bless the fork that pitched me," is his emphatic declaration. Content to do good work, he has not striven to rise out of his profession or craft, but has struggled wisely and well to make himself and his vocation better and higher by well directed efforts within its sphere. His motive in publishing this book is as praiseworthy as is the contentment displayed. He entertained the hope of diffusing a sounder taste for art, of elevating the standard of the printing craft itself. He learnt to recognise the vulgarity often displayed by an appeal to the meretricious and the tawdry in decoration, and he fights relentless warfare against the monstrosities of printing that occasionally disfigure our journals and deface our walls. The posters of Mr. Vincent Crummles, in which appeared "letters afflicted with every kind of spinal deformity" would find no favour with the advocate for the genuine decoration that consists in good workmanship.

Mr. Thorp looks for allies where one would least expect to find them. He writes for the mercantile class, who, seeking their goal by the beacon light of success, find printing necessary for the spread of information connected with business. He would enlist those who display the predominant commercial spirit in its most vigorous form in his crusade against bad taste and injudicious decoration. He entertained the hope of creating some "enthusiasm for a fine craft, and of inducing some of those who came with mere thoughts of business, to go a little further and do something for the raising of the general standard of taste; even if there were no money in it." This aim is to make work as thorough as its effective production will permit, confident that any increased expenditure will be compensated by a greater measure of success. Typography itself was an evolution that required a suitable environment for its full development, and its general adoption by individuals for special purposes, permitting the exercise of personal control, may have the happy result of introducing a higher standard of design and execution.

The author makes a few pertinent remarks on general methods of printing, but these apply almost entirely to hand setting. Rapidity of execution plays no part in his programme, and therefore machine composing is not considered. Elaborate 'display' settings are beyond the range of linotype or monotype machines, and certain faces of type, admirable in themselves and to be recommended for private work, are not suitable for those machines. The plan and make up of the page, or book, so as to ensure the best decorative effect, understanding by decorative, clearness and simplicity, are matters on which he invites the client's co-operation. In these explanatory chapters, we learn how much has to be accomplished by experts after the copy has been placed in the hands of the printer. The mysteries and importance of head margins and back margins, of fore edge and making up the "dummy" are explained, and by the employment of contrasts in which the well arranged page is brought into juxtaposition with one ill arranged, the author seeks to cultivate our taste and to convince those who hitherto have cared for none of these things, how much they are indebted to the instructed printer, who gives a good and dignified appearance to their work. The author draws the conclusion that there is no reason why any man of intelligence should not thoroughly master the traditions of the craft that deal with the arrangement and appearance of the printed page. Perhaps he is right, but the interference of the half instructed is a questionable advantage, and those probably are wise who place themselves unreservedly in the expert's hands, though the latter may occasionally be tempted to sacrifice convenience of reference to neatness of arrangement, and play other tricks that are equally irritating.

In the matter of illustration or diagrams, the author seems to be of the same opinion, for he clearly asserts that "it is the kind patron, interfering with the artist that is responsible for much bad work," "and I regret to have to say that the patron is not always the best judge. Ability to pay a bill does not confer all the talents." In this connection, it is pleasant to have the decision of one who has had much experience in circulating illustrated advertisements and in catering to the general demand for ornament, that no mistake is more common than the underrating of public taste. In consequence of this mistaken contempt, the attention compelling power of the good craftsman as compared with that of the poor is overlooked, under the impression that uncultivated people cannot appreciate the difference between good and inferior work.

It is not so satisfactory to find that good hand work, whether required for a wood-cut or for a fine line drawing is rapidly disappearing owing to the demand of the public for something "just as good" and cheaper. We regret it. Wood-cut printing at its best could render the lights as clear and the shadows as black as from a steel plate. A bewildering number of devices connected with photo-mechanical processes for multiplying copies of the original drawing have supplanted the engraver. Process work may make a more exact facsimile of the original pen drawing than the most skilful engraver can do, but it finds its limitations in the artistic interpretation, which a great artist engraver can give to a work, and to which the best mechanical work can only approximate. Line by line with exquisite patience, the engraver reproduces the original, his tools are simple but his manipulation perfect, there is no secret beyond the eye careful to see, the hand deft to cut, and the trained artistic judgment which dictates the right kind of direction and width of line to interpret the artistic feeling. The prospect of a lost art is ever a misfortune.

Bookbinding seems outside the purview of this little volume, but inasmuch as the finished book gives opportunity for the display of good or bad workmanship it is within the author's scope to call attention to some points that are apt to be disregarded. He recognises three classes of books that will of necessity require binding, those that must be bound as well as possible, regardless of expense, some as cheaply as they can be bound well, and others as well as they can be bound cheaply. But in whatever fashion a book may be bound, or put in cases, he insists on the observance of the elementary rule of craft honesty, that materials should look what they are. Cloth should be, frankly, cloth, and not ape the qualities of leather. Fraud, in however a seductive form, should be eschewed. Shoddy in any guise is not to be tolerated. This is the lesson the author seeks to bring home in binding as elsewhere. A true work of art does not consist in some special artifice that satisfies the caprice of changing fashion or the dictum of some loud voiced authority, but in every industry is the result of worthy and complete workmanship by honest and competent workmen.

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## BOOKS RECEIVED.

*Fuel, Water and Gas Analysis for Steam Users.* By JOHN B. C. KERSHAW, F.I.C. Second edition, revised and enlarged. London: Constable and Co., Limited. [Price 12*s.* 6*d.* net.]

*Principles and Practice of Electrical Testing.* By R. G. Allen, B.Sc.(Lond.). London: Longmans, Green and Co. [Price 18*s.* net.]

*Mensuration for Marine and Mechanical Engineers.* By JOHN W. ANGLES, M.Sc.(Eng.). London: Longmans, Green and Co. [Price 5*s.* net.]

*A Plain Guide to Investment and Finance.* By T. E. YOUNG, B.A., F.R.A.S. Third edition, revised. London: Macdonald and Evans, 29, Essex-street. [Price 7*s.* 6*d.* net.]

*A Text Book of Aeronautical Engineering.* By Lieutenant ALEXANDER KLEMIN, S.M., B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 15*s.* net.]

*Efficient Boiler Management.* By CHARLES F. WADE. London: Longmans, Green and Co. [Price 12*s.* 6*d.* net.]

*Elements of Vector Algebra.* By L. SILBERSTEIN, Ph.D. London: Longmans, Green and Co. [Price 5*s.* net.]

*The Costing Problem.* By EDWARD T. ELBOURNE. London: The Library Press, Limited, 26, Portugal-street, W.C. 2. [Price 4*s.* 6*d.* net.]

*The Law Relating to Housing and Town Planning in England and Wales.* By W. ADDINGTON WILLIS, LL.B.(Lond.). London: Butterworth and Co. [Price 20*s.* net.]

*The American Boy's Engineering Book.* By A. RUSSELL BOND. Philadelphia and London: J. B. Lippincott and Co. [Price 8*s.* 6*d.* net.]

*Foundry (Iron, Steel, Brass, &c.).* Foster's Pocket Reference Books. No. 3. Manchester: Frank Foster, 98, College-road, Whalley Range. [Price 2*s.* net.]

*Machine and Fitting Shop Practice.* Vol. II. By GEORGE W. BURLEY, Wh.Ex. London: Scott, Greenwood and Son. [Price 6*s.* net.]

*British Rainfall, 1918.* By HUGH ROBERT THIEL and M. DE CARLE S. SALTER. London: Edward Stanford, Limited. [Price 10*s.*]

*Notes on Magnetism for the Use of Students of Electrical Engineering.* By C. G. LAMB, M.A. Cambridge: The University Press. [Price 5*s.* net.]

*Imperial Institute. Monographs on Mineral Resources. Tin Ores.* By G. M. DAVIES, M.Sc.(Lond.), F.G.S. *Manganese Ores.* By A. H. CURTIS, B.A.(Lond.), F.G.S. London: John Murray. [Price 3*s.* 6*d.* net each.]

*The Profession of Chemistry.* By RICHARD B. PILCHER. London: Constable and Co., Limited. [Price 6*s.* 6*d.* net.]

*Line Charts. (For Solving Engineering Formulæ.)* By ERNEST W. TIPPLE. Leeds: Sub-Branch Association of Engineering and Shipbuilding Draughtsmen, 28, Arthington View, Hunslet. [Price 2*s.* net.]

*Hill's Portuguese-English and English-Portuguese Vest Pocket Dictionary.* Compiled by LEONORA DE ALBERTI. London: Leopold B. Hill, 2, Langham-place. [Price 2*s.* net.]

*The Briton in Flanders. A Pocket Interpreter containing Phrases and Travel Talk, &c.* By E. V. BISSCHOP. London: Leopold B. Hill, 2, Langham-place. [Price 1*s.* 6*d.* net.]

*A Diving Manual and Handbook of Submarine Appliances.* By R. H. DAVIS. London: Siebe Gorman and Co., Limited, 187, Westminster-bridge-road. [Price 7*s.* 6*d.*]

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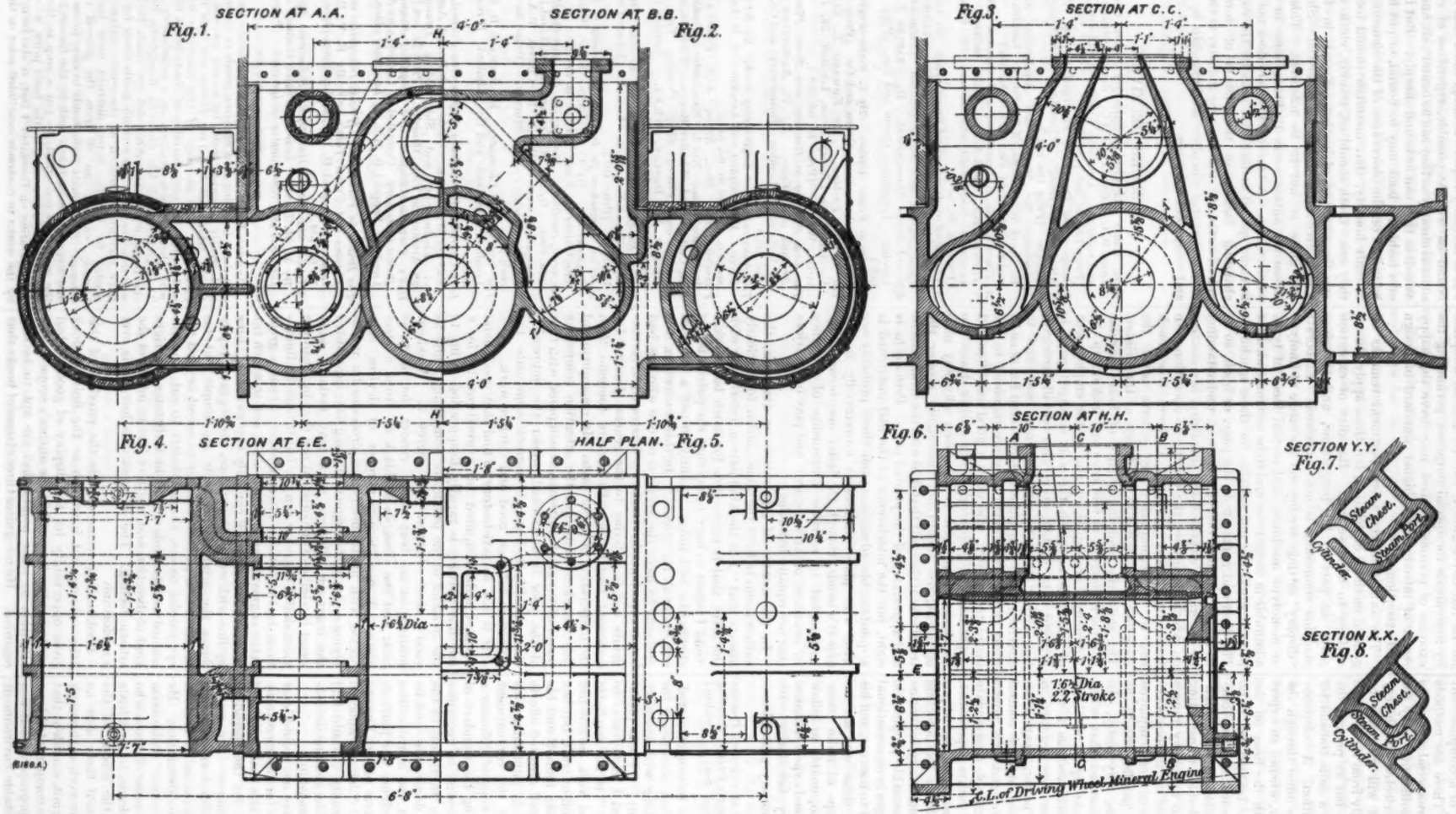
GERMAN IRON TRADE.—Both manufacture and wholesale firms handling iron and iron goods in Germany are still greatly inconvenienced by several adverse circumtanc s, which are becoming rather the rule than the exception. The shortage of raw materials continues, and so does the utter inability of the railways to grapple with the transport problem in a satisfactory manner. Thus goods which left works in Westphalia by rail in the beginning of December did not reach Berlin until well into January. As a result goods ready for delivery have had to be stocked at the works although badly needed by buyers. Some districts have been, temporarily, entirely cut off from the general transport scheme. Illegitimate trade tends to raise prices unduly, and steps are being taken both by the Government and the industries concerned, to put a stop to this abuse. The rise of 60 per cent. in the basis price, which came into operation on December 1 last, is also being applied by the works to contracts concluded prior to that date.

# CYLINDERS OF 0-8-0 TYPE SUPERHEATER LOCOMOTIVE; NORTH-EASTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S DARLINGTON WORKS, TO THE DESIGNS OF SIR VINCENT L. RAVEN, K.B.E., M. INST. C.E., CHIEF MECHANICAL ENGINEER.




SUPPLEMENTING our recent account of the new 0-8-0 type three-cylinder locomotives on the North-Eastern Railway, we are now able, by the courtesy of Sir Vincent L. Raven, K.B.E., to give illustrations of the cylinders, and also some diagrams showing the performance of these engines on the road. In our issue of the 16th ult. (page 83 *ante*) we corrected a previous misstatement with regard to the cylinders. These it will now be clearly seen are all contained in one casting, together with the valve-chambers.

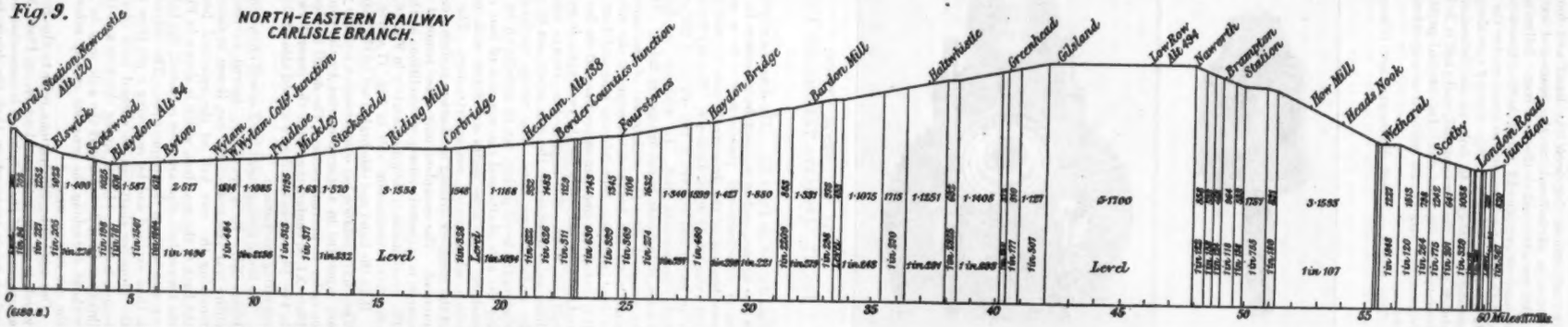
Figs. 1, 2 and 3 give cross-sections through the casting, Fig. 1 being through the steam ports. As the valves and ports are identical for all three cylinders this section runs through one port of the centre cylinder and the outside cylinders. Fig. 2 is a section at B B, Fig. 6. This section is taken through the steam inlet to the steam chest, and shows the latter to be common to all three cylinders. It also shows the passages from the ports to the cylinders. Fig. 3 is a section at C C, Fig. 6, *i.e.*, on the centre line of the casting. It gives a section through the exhaust passages, which are separated up to the level of the base of the blast pipe. Fig. 4 is a horizontal section taken through the centre line of the cylinders, and therefore also through the valve-chamber of the outside cylinder. Fig. 5, facing it, is a plan of the casting. Fig. 6 shows a longitudinal section taken on the centre line of the engine, *i.e.*, through the centre cylinder and its superposed valve. Figs. 7 and 8 are two details of the passages shown in Fig. 2. The cylinders are set on an incline of 1 in 9.

These engines are designed to handle loads of 1,400 tons on inclines of 1 in 200. In Fig. 9 we show the profile of the North Eastern Railway Carlisle branch, on which many of the grades are steeper than this; while Figs. 10 and 11 give the diagrams taken in the dynamometer car behind the engine on a trip over this road, with a load of 1,402 tons. The run was from between Blaydon Mineral Sidings to Carlisle. The train consisted of the dynamometer car, 60 loaded coal wagons and a brake van. The upper diagram, Fig. 10, shows the speed curve, which also shows the kinetic energy of the engine and train at any point, the booked time, actual running time, time allowed for signal checks, and time of passing every fifth mile post. The lower portion of the diagram, Fig. 11, shows the drawbar pull in tons, from point to point, and the average pull between points. Below is shown the amount of work done to any point in 101 car units. One car unit is taken as 330,000 ft. lb. of work, or 10-h.p. minutes. For example, the work being done at the 19th mile post was 35 × 101, or 3,535 car units, and so on. The drawbar horse-power developed on various stretches of the run is given in this diagram in a chain dotted curve, which is not continuous for the whole trip. At the 15th mile post it will be noticed

# TRIALS OF 0-8-0 TYPE SUPERHEATER LOCOMOTIVE; NORTH-EASTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S DARLINGTON WORKS, TO THE DESIGNS OF SIR VINCENT L. RAVEN, K.B.E., M. INST. C.E., CHIEF MECHANICAL ENGINEER.

*Fig. 9.*




*Speed, Pull and Draw-Bar Horse Power Engine N°. 901.*
*Load in Tons. 1402.*
*N°. of Vehicles. 60 Loaded Wagons, Van & Car. Date 14 Nov. 1919.*

*R.F.O. means regulator full open*
*R.5 " " lever is midway on quadrant*
*One Horse Power Minute is 33,000 foot Pounds of Work*

*650 or similar number means temperature of steam in header of superheater*
*175 or similar number means boiler pressure in pounds per sq. inch*
*N5 " " " is 5 notches from the centre.*

*Fig. 10.*

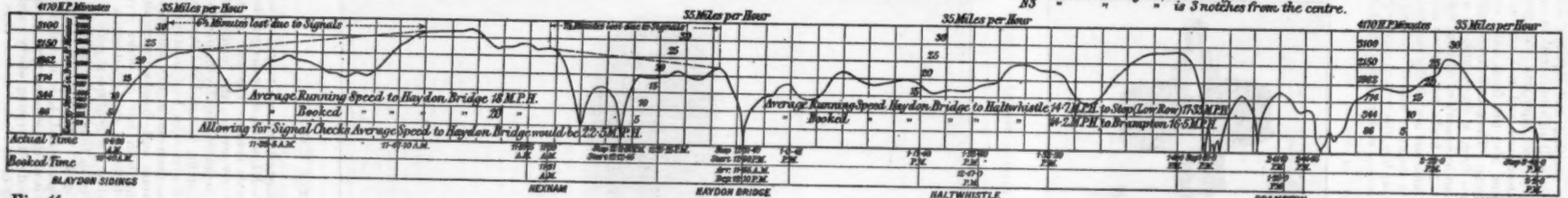
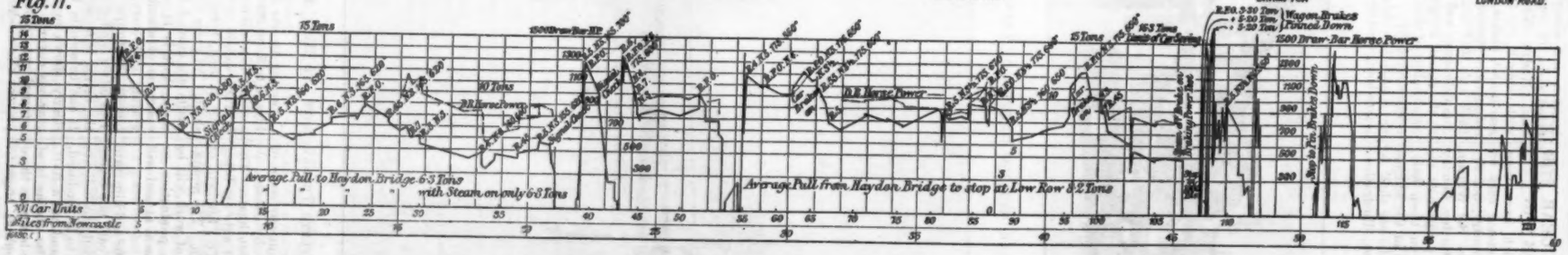

4170 H.P. Minutes
35 Miles per Hour
6½ Minutes lost due to Signals
Average Running Speed to Haydon Bridge 18 M.P.H.
Booked " " " " 20 "
Allowing for Signal Checks Average Speed to Haydon Bridge would be 22·5 M.P.H.
Actual Time
Booked Time
BLAYDON SIDINGS
HEXHAM
HAYDON BRIDGE
Average Running Speed Haydon Bridge to Haltwhistle 14·7 M.P.H. to Stop (Low Row) 17·33 M.P.H.
Booked " " " " 14·2 M.P.H. to Brampton 16·5 M.P.H.
HALTWHISTLE
BRAMPTON
LONDON ROAD.

*Fig. 11.*


15 Tons
1500 Draw-Bar H.P.
Average Pull to Haydon Bridge 6·3 Tons
" " " with Steam on only 6·8 Tons
Average Pull from Haydon Bridge to stop at Low Row 8·2 Tons
D.B. Horse Power
Wagon Brakes Pinned Down
1500 Draw-Bar Horse Power
Stop to Pin Brakes Down
(1) Car Units
Miles from Newcastle

that the drawbar horse-power exceeded 1,100. The interpretation of the abreviations and initials given at various points, and which refer to boiler and reversing gear conditions, are shown above Fig. 10.

Starting from Blaydon Mineral Sidings, near the 4th mile post, with a pull of over 13 tons, a speed of 25 m.p.h. was attained at the 7th mile post, after which a series of signal checks reduced the speed as shown, and at the 18th mile post the speed was 33 m.p.h. Signal checks caused the speed to be reduced to 6 m.p.h. at the 21st mile post and the train to be brought to rest at the 22¼ mile post. The engine could easily have maintained a speed which is shown by the dotted lines on the speed curve, which would have given an average speed of 22·5 m.p.h. between Blaydon and Haydon Bridge.

Starting from Haydon Bridge, near the 28th mile post, with a pull of 12 tons, a speed of 17 m.p.h. was attained at the 30th mile post, where the car brake was applied with a force which was equivalent to an extra load of 300 tons, and this caused a reduction in speed of 17 m.p.h. to 13 m.p.h. The car brake was again applied at Greenhead, on a gradient of 1 in 177, with similar results. Near the 45th mile post, a brake test was made. The driver was instructed to bring the train to rest without shock when going at 28 m.p.h. To do this, he reduced the speed 3 m.p.h. in the first 520 yards, and brought the train to rest in the next 780 yards, which required an average retarding force of 13·5 tons. At the 46th mile post, a maximum pull test was made. To obtain this, three 30-ton and ten 20-ton wagon brakes had to be pinned down, the result being that the car spring was pulled out to its full extent, which is 16·3 tons. The remainder of the trip to Carlisle is mostly on the down grade, and wagon brakes had to be pinned down to regulate the speed of the train.

For the return trip from Carlisle to Blaydon, the load consisted of the dynamometer car, 60 loaded goods wagons and a guard's van, which made a total approximate weight of 787 tons. The train was stopped at How Mill on a gradient of 1 in 107, where the load was easily started with a pull of 12½ tons, and the speed increased to 16 m.p.h. in 7 minutes. The average pull, including the starting pull for the 4 miles of gradient of 1 in 107 was 9·1 tons, which, added to the pull due to gravity on engine and tender, makes a pull of 10·4 tons at the engine wheels. After passing Naworth, it will be seen that the brake power of the engine was the factor which determined the load.

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PIG-MOULDING BY MACHINERY.—*The Iron Age* describes a method of making the moulds for pig-iron by machine, in use at the works of the Central Iron and Coal Company, Holt, Ala., U.S.A. In this system the patterns are mounted on a cylinder as long as the pig-iron bed is wide. The sand bed is first prepared by levelling by means of a drag, and the cylinder with its patterns is then run over it. If an overhead crane is available the cylinder can be suspended from it and run over the beds. If not, a small winch at the end of the bed will serve the purpose. The method is extremely simple and is said to be entirely satisfactory. It is very expeditious and results in a great saving of time and labour.

## TRANSMISSION AND CONTROL GEAR FOR ANGUS SANDERSON MOTOR CAR

Among the many programmes which have been inaugurated for the manufacture of motor cars on repetition lines, and in bulk, in this country, not the least interesting is that due to Messrs. Sir William Angus Sanderson and Co., Limited, of Birtley, County Durham. The general features of this programme are well known, and we need not dwell on them here. It is sufficient to say that an essential of the scheme is that each of the various details of the car shall be made by a specialist firm. The engines, illustrations and a description of which appeared in our issue of November 21 last, are manufactured by Messrs. J. Tylor and Sons, Limited, of New Southgate. The transmission and control gear and front axle are being made by Messrs. E. G. Wrigley and Co., Limited, of Foundry-lane Works, Soho, Birmingham. The reputation of Messrs. Wrigley for this class of work will be sufficient evidence alone that, mass production or otherwise, a high class car is being aimed at and will be produced.

The purpose of this article is to describe and illustrate Messrs. Wrigley's contribution to the car, but before proceeding to details it will be well briefly to indicate the main features of the model which is to be produced. The car is to carry a four-seater body and has a 10-ft. wheel base, with 4-ft. 4 in. track. The engine is of 14·2 h.p. (Treasury rating) and the gear-box gives three forward speeds and reverse. High-tension magneto ignition and electric starting and lighting sets are fitted as is, of course, well-nigh universal in modern cars. Messrs. Wrigley are supplying the gear-box with controls, the transmission and back axle with the rear wheel brakes, and also the front axle, steering column and steering gear. The gear-box, transmission, back axle and brakes form a single unit in a very complete sense, and can be assembled without reference to the chassis frame. The brake connections are quite independent of this frame and are wholly carried on the transmission unit. In the same way the control levers are mounted on the gear-box, the central control, which is now being used by several makers, being adopted.

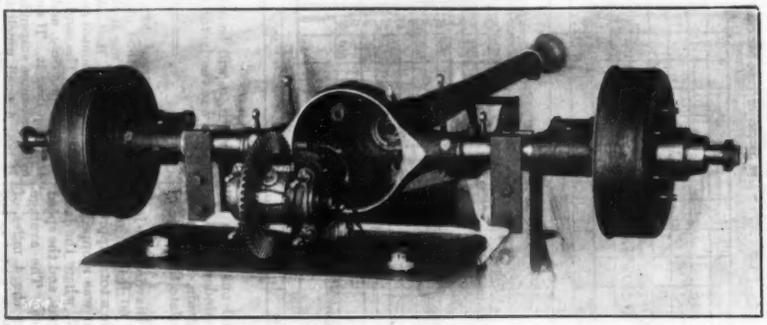

Fig. 15. Rear Axle, showing Removal of Transmission Gear.

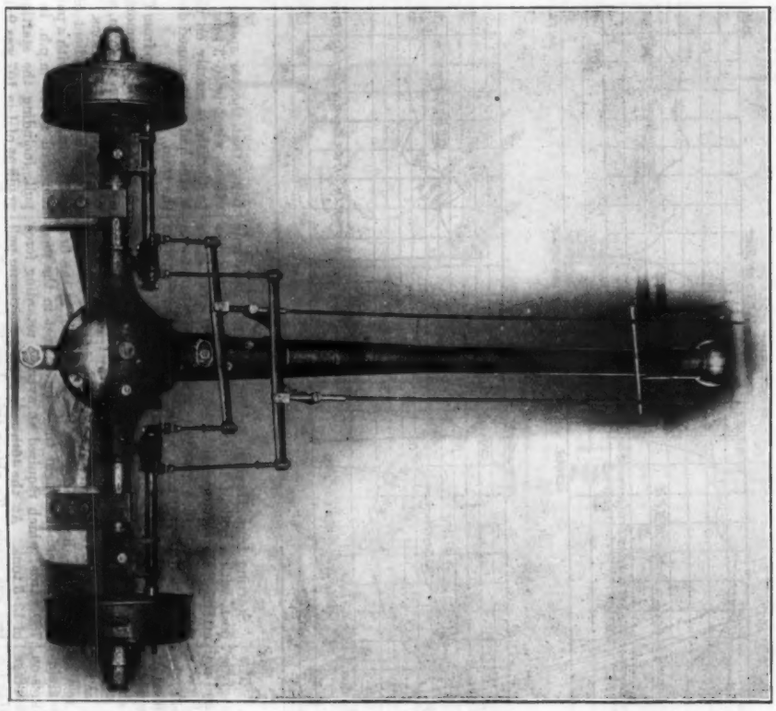

Fig. 18. Complete Transmission and Back Axle Unit.

Turning to our illustrations, we may first refer to Figs. 1 to 5, on Plate XI, which show the gear-box and controls in considerable detail. The gear gives three forward speeds and one reverse, the countershaft, as will be seen, being mounted directly below the main shaft. All gears are spline mounted and the gears and shafts are ground all over after heat-treatment. The main shaft is 1¼ in. diameter in the bearings. The casing is of aluminium and, besides containing the gearing and carrying both sets of brake levers, it houses the torque ball and the speedometer drive. This latter is effected by a pair of spiral gears of which the driver is mounted in front of the universal joint. It can be seen in Fig. 1. The change-speed lever, as clearly shown in Figs. 1 and 4, is mounted on the gear-box cover. It is of the selected type, having an internal gate provided with spring safety catches to prevent the meshing of two gears at one time. The hand-brake lever arrangement is shown in Figs. 3 and 4. The adjustment for both the hand and foot brake control is carried out on the brake-rod extensions, which are attached to the gear-box. Adjustment can be made at any time by lifting the floor boards of the car and there is no necessity to crawl under the chassis. It will be gathered from Figs. 1 and 2 that the gear-box casting is arranged to bolt to an extension of the clutch pit at the forward end, and that it is hung on trunnions at the rear end. Its internal parts can all be removed without disturbing it or any other part of the car.

The rear axle, and differential are illustrated in

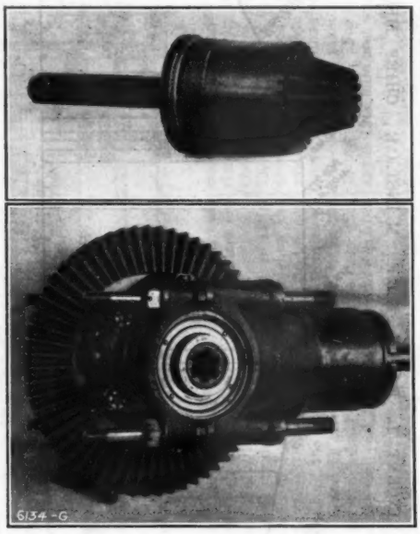


Fig. 16. Bevel Pinion.
Fig. 17. Complete Transmission Unit.

Figs. 6 to 10, on Plate XI. The details are well shown in the figures, and it will not be necessary to refer to minor constructional points here. As a guide to consideration of the drawings it may be said that the rear axles are 1½ in. in diameter. Facility for overhaul is an important feature of the whole of the rear axle and transmission unit. In addition to detachable wheels, detachable brake drums are fitted. These can be removed after the withdrawal of two screws. To remove all the brake shoes requires the withdrawal of four split pins, four fulcrum pins and four springs. It is stated that one man can replace all the brake shoes and have the car ready for the road again in well under half an hour. To inspect the crown wheel and differential mechanism the rear cover can be removed by undoing four nuts. The whole mechanism, including the bevel pinion, can be withdrawn by extracting the axle shafts and the removal of four nuts and washers. The axle shafts are fitted with jack nuts which, when rotated, act as extractors. The removal of the complete driving mechanism is shown in Fig. 15, annexed. The complete unit after removal may, of course, be adjusted under good conditions on the bench. The bevel pinion is shown separately in Fig. 16, and the complete transmission unit in Fig. 17 above.

Both the hand and side brakes act on the rear wheels. They have balance-bar compensation and the pull rods are supported in a stirrup carried by the torque tube in order to prevent rattle. The detail in Figs. 6 to 9, Plate XI, in conjunction with the general view given in Fig. 18, annexed, will give a good idea of this brake-operating mechanism.

The brake arrangement itself is well shown in Fig. 10, Plate XI. If it should be desired to remove the entire rear axle unit of the car, it can be done by first removing the rear half of the spherical housing at the back of the gear-box, which is shown in Fig. 1. If the torque ball clips are then removed, the ball can be screwed back on the torque tube. The universal joint is then exposed and by removing a pin from the joint the propeller shaft can be slipped back clear of the torque housing. If the spring shackles and the brake links are then disconnected the axle may be removed without disturbing the gear-box or any other part of the car in any way.

Our remaining illustrations refer to the front axle, which is shown in Figs. 11 to 14, on Plate XI. The arrangement of the axle heads is somewhat novel, the swivel being arranged so that the inner bearing is brought inside the swivel pins. This construction has

the advantage of making the spread of the bearings almost double the usual amount, and at the same time furnishes an oil reservoir to feed all points requiring lubrication on the front axle. The design also makes a straight front axle possible, and provides spring seatings in such a position that the centre of gravity is kept low, and furthermore a good ground clearance is attained. The general lay-out of the axle is shown in Figs. 11 and 12, while enlarged details of the swivel arrangement are given in Figs. 13 and 14. In addition to the parts we illustrate, Messrs. Wrigley are also supplying the steering gear for the car. This is of the worm-wheel type with a full wheel. The gear case is of aluminium, and there is only one reservoir for oil. The ball on the steering lever is supplied with lubricant from this case by means of a small copper tube. The drag link is spring-loaded to take up wear on the ball, and the axle ends are provided with a cross-pin universal joint, which is also lubricated from the stub-axle sleeve. The ball and roller bearings throughout the whole gear are of Hoffmann make.

## THE AIR COOLING OF PETROL ENGINES.*

By A. H. GIBSON, D.Sc., University College, Dundee.

1. THE theory of the air cooling of the petrol engine has been investigated in a very comprehensive paper read before this Institution by Mr. F. W. Lanchester in 1915.† It is not intended to deal with this side of the question in the present paper, which records some of the results of experimental work on air-cooled engines carried out by the author and his colleagues between the years 1916–19. This work was carried out almost entirely on aero engines having cylinder sizes somewhat larger than those adopted in automobile practice. It is, however, hoped that the results may be of some use in the design of air-cooled engines suitable for car work, and that the paper may serve to supplement that of Mr. Lanchester.

2. *Laws of Air Cooling.*—The cooling surfaces of the modern air-cooled cylinder almost invariably take the form of a series of fins, though in some special cases cooling spikes may be used with advantage over certain portions of the cylinder. A large number of tests have been made to determine the rate of heat dissipation from such surfaces, with results which show that for wind speeds between 20 m.p.h. and 60 m.p.h. the heat loss is sensibly proportional to the mean temperature-difference between the fin surface and the incoming air, and to the 0·73 power of the wind speed. For a given material the heat dissipation is sensibly independent of the roughness of the surface. Different materials have slightly different dissipation coefficients. A steel surface appears to give somewhat greater heat dissipation than an aluminium or a copper surface, the difference being, however, only about 5 per cent. to 10 per cent. The dissipation from cast aluminium fins appears to be improved by a coating of suitable stoving enamel, the difference between the enamelled and plain fins being about 10 per cent. Over the range of cylinder sizes usual in practice, the dissipation coefficient is sensibly independent of the cylinder diameter. A large number of tests have been made to determine the heat loss from finned cylinders in a parallel air blast, with results which indicate that, for copper fins, this heat loss is given by :

$$\sigma = (0{\cdot}0247 - 0{\cdot}0054\,(l^{0{\cdot}8}/p^{0{\cdot}4}))\,V^{0{\cdot}73}$$

in Centigrade heat units per square foot per minute per degree Centigrade of difference between the mean temperature of the fins and that of the incoming air.

Here $l$ is the length of the fins in inches.
$p$ is the pitch in inches, measured from surface to surface of adjacent fins.
V is the wind speed in miles per hour.

This relationship has been deduced from tests on cylinders having diameters ranging from 1·25 in. to 3·75 in., with fin lengths ranging from 0·63 in. (16 mm.) to 1·62 in. (41 mm.), and with pitches ranging from 0·1575 in. (4 mm.) to 0·75 in. (19 mm.). Where the fins are of tapering section, the value of $p$ should be taken at the mean height of the fin.

3. *Shape and Size of Fins.*—The fin which gives the maximum heat-loss per unit of weight is one having slightly concave surfaces and a sharp tip. It may be shown, however, that a plain triangular fin is only very slightly less efficient. The best proportions for such a fin depend on the conductivity of the material and on the wind speed. For a speed of 40 m.p.h., Table I shows the best proportions for such fins of aluminium alloy (conductivity = 0·38 C.G.S. units) and steel (conductivity = 0·10 C.G.S. units) and also for rectangular copper fins (conductivity = 0·90 C.G.S. units).

TABLE I.

| Bottom Breadth "B" Cm. | 0·025 | 0·05 | 0·1 | 0·2 | 0·3 | 0·4 | 0·5 |
|---|---|---|---|---|---|---|---|
| Length, cm.— | | | | | | | |
| Aluminium .. | — | — | 2·0 | 2·9 | 3·5 | 4·1 | 4·5 |
| Steel .. .. | — | — | 1·1 | 1·5 | 1·8 | 2·1 | 2·3 |
| Copper .. .. | 1·6 | 2·3 | 3·3 | 4·8 | — | — | — |

If such a fin be truncated until the tip breadth is one-fifth of the bottom breadth, the lengths become 80 per cent. of those given above. The heat dissipation is about 0·88 times and the weight 0·96 times as great as for the complete triangular fin.

Since the heat dissipated from a fin of given shape varies directly as the length of the fin, while the weight varies as the square of the length of the fin, other things being equal, cooling fins should be as short as possible, a large number of short thin fins being used in preference to a smaller number of longer and thicker fins. While in practice this is to be borne in mind, many other factors besides that of weight have an important bearing on the best size of fin to be adopted. Thus, in a thin steel cylinder, or in a cylinder of cast-iron or cast aluminium alloy, the circumferential ribs add greatly to the strength and resistance to distortion. Comparatively deep and heavy fins have a greater effect in this direction than a larger number of similar but smaller fins giving the same cooling. Again, as the number of fins is increased, the pitch is correspondingly diminished. This diminution in pitch reduces the air flow between the fins to an extent which may, with very small pitches, render the fins practically useless for cooling purposes.

In a cylinder of cast-iron or of aluminium alloy, foundry difficulties put a definite limit to the minimum pitch of the fins. On the barrel itself a somewhat smaller pitch may be adopted than on the head, or the barrel fins may be turned out of the solid if desired. On account of the complicated form of the cylinder head and ports, however, it is impossible to machine their cooling fins, and the length of many of the cores necessitates the pitch being made fairly large. The minimum practical pitch of fin for such cylinders, having a diameter of from 4 in. to 6 in., is about 8 mm. to 9 mm., or about $\frac{1}{3}$ in. Foundry difficulties also prevent the casting of a fin having a tip less than about 0·5 mm. in thickness, or a root thickness less than about $l/10$, so that an aluminium fin 1 in. long would not have a root thickness less than 0·1 in.

For steel cylinders with fins turned out of the solid, the pitch may, with advantage, be cut down to about $\frac{1}{8}$ in. on a cylinder of 3 in. or so in diameter, but there appears to be little to be gained by reducing the pitch beyond this point.

4. *Variation of Cooling with Density of Air.*—The cooling intensity of an air blast depends on the weight of air brought into contact with the cooling surfaces in unit time. In the case of an aero engine, the density of the air varies considerably with the height. The weight involved in cooling is proportional to $\rho V$, and the heat dissipated from a finned surface is proportional to $(\rho V)^{0{\cdot}73}$. In the case of an automobile engine the variation in density may, in general, be neglected except for units designed for operation at high altitudes.

5. *Heat to Cylinder Walls and Piston.*—The amount of heat transmitted from the working fluid to the walls and piston of an internal-combustion engine depends upon a number of factors, including :—

(*a*) The design of the cylinder.
(*b*) The strength of the working mixture.
(*c*) The spark advance.
(*d*) The compression ratio.
(*e*) The fuel used.
(*f*) The speed of rotation.
(*g*) The size of the cylinder.

The bearing of these various factors will be considered at a later stage.

Since the heat transmission from the fluid to the walls during its most important stage, i.e., during and directly after explosion, is largely due to radiation, and is therefore probably approximately proportional to $(T_g^4 - T_w^4)$, where $T_g$ and $T_w$ are the absolute temperatures of the gas and the walls, any such difference of wall temperature as is likely to exist in practice between an air-cooled engine and a water-cooled engine can have little effect on the rate of heat transmission. As a matter of fact, such measurements as have been made show that the differences in wall temperature, piston temperature, and exhaust valve temperature, between a well-designed air-cooled cylinder and the corresponding water-cooled cylinder, are small, and that unless the water-cooling system is well arranged, the air-cooled cylinder may be, and often is, actually the cooler of the two.

In view of this, since it is much easier to obtain a measurement of the heat flow through the cylinder walls of a water-cooled engine than through those of an air-cooled engine, where such heat loss can only be determined from the heat balance sheet by differences, such determinations have usually been made on water-cooled engines. It is true that, since the water jacket surrounds the exhaust port or a short length of the exhaust pipe, the heat measured in this way includes a proportion of heat which should, correctly, be included among the heat of the exhaust, but as in both cases this heat has ultimately to be dissipated, in the one case by the radiator and in the other case by the cooling fins, this

TABLE II.

| Test Series No. | Engine. | Compression Ratio. | Revolutions per Minute. | B.H.P. | Petrol, Lb. per B.H.P. per Hour. | Heat from Working Fluid Expressed as H.P. (A). | Heat from Cooling Surfaces in 60-Mile Wind (H.P.). | A B.H.P. |
|---|---|---|---|---|---|---|---|---|
| 1 | R.A.F. 3A 12-Cyl. Vee. Cyls. 4½ in. by 5½ in. | 4·7 | 1,100<br>1,400<br>1,700 | 155·7<br>190·4<br>214·0 | 0·520<br>0·535<br>0·548 | 144·0<br>175·0<br>204·3 | 87·0<br>67·5<br>68·0 | 0·925<br>0·913<br>0·950 |
| 2 | *Hispano Suiza*<br>8-Cyl. Vee. Cyls. 4·72 in. by 5·11 in. (120 mm. by 130 mm.) | 4·8 | 1,000<br>1,200<br>1,400<br>1,600 | 107·0<br>130·0<br>150·0<br>168·0 | 0·595<br>0·587<br>0·584<br>0·580 | 100·0<br>115·0<br>132·0<br>143·0 | 62·0<br>62·0<br>62·0<br>62·0 | 0·93<br>0·89<br>0·88<br>0·85 |
| 3 | *Fiat*<br>6-Cyl. straight line. Cyls. 6·3 in. by 7·08 in. (160 mm. by 180 mm.) | 5·3 | 1,000<br>1,250 | 195·5<br>244·0 | 0·589<br>0·579 | 163·0<br>195·0 | 51·0<br>51·0 | 0·83<br>0·80 |
| 4 | *Renault*<br>12-Cyl. Vee. Cyls. 4·92 in. by 5·90 in. (125 mm. by 150 mm.) | 4·8 | 1,200 | 224·0 | — | 216·6 | 69·0 | 0·97 |
| 5 | *Sunbeam*<br>12-Cyl. Vee. Cyls. 3·74 in. by 5·22 in. (95 mm. by 135 mm.) | 5·2 | 2,100 | 223·0 | 0·520 | 190·0 | 65·0 | 0·89 |
| 6 | *Mercedes*<br>Single-Cylinder. Cyl. 6·3 in. by 7·08 in. (160 mm. by 180 mm.) | 4·5<br>5·0<br>5·5<br>6·0 | 1,400<br>1,400<br>1,400<br>1,400 | 26·9<br>27·4<br>28·2<br>28·0 | 0·551<br>0·563<br>0·565<br>0·586 | 23·2<br>22·2<br>22·0<br>20·7 | No wind<br>No wind<br>No wind<br>No wind | 0·86<br>0·81<br>0·78<br>0·74 |
| 6 | Do. do. | 4·5<br>5·0<br>5·5<br>6·0 | 1,600<br>1,600<br>1,600<br>1,600 | 30·3<br>30·9<br>31·6<br>31·4 | 0·593<br>0·585<br>0·593<br>0·585 | 25·2<br>24·1<br>23·1<br>21·7 | No wind<br>No wind<br>No wind<br>No wind | 0·83<br>0·78<br>0·73<br>0·69 |
| 7 | *Ricardo Tank Engine*<br>6-Cyl. straight line. Valves in side pockets with inlet over exhaust. Crosshead piston. Cyls. 5·625 in. by 7·5 in. (143 mm. by 190 mm.) | 4·3 | 1,200 | 162·9 | 0·554 | 164·2 | No wind | 1·10 |
| 8 | *Adler "L" head Motor Car Engine*<br>4-Cyls. Cyls. 3·38 in. by 5·31 in. (86 mm. by 135 mm.) | 4·2 | 1,200<br>1,400<br>1,600<br>1,800<br>2,000<br>2,200 | —<br>—<br>—<br>—<br>—<br>— | 0·620<br>0·590<br>0·571<br>0·570<br>0·580<br>0·605 | —<br>—<br>—<br>—<br>—<br>— | No wind<br>No wind<br>No wind<br>No wind<br>No wind<br>No wind | 1·58<br>1·51<br>1·46<br>1·43<br>1·45<br>1·51 |
| | *Air Cooled Cylinders.* | | | | | | | |
| 9 | *Air-cooled single aluminium cylinder with overhead valves*<br>Cyl. 3·94 in. by 5·51 in. (100 mm. by 140 mm.) | 4·6 | 1,600<br>1,800<br>1,800<br>2,000<br>2,000 | 14·6<br>16·2<br>15·1<br>16·1<br>15·3 | 0·513<br>0·542<br>0·516<br>0·534<br>0·522 | 15·6<br>18·8<br>16·4<br>17·7<br>16·2 | In wind 64 m.p.h.<br>8·1<br>8·8<br>8·1<br>8·4<br>8·0 | 1·07<br>1·16<br>1·09<br>1·10<br>1·06 |
| 10 | *Air-cooled single aluminium cylinder with overhead valves*<br>Cyl. 4·5 in. by 5½ in. (114 mm. by 139·5 mm.) | 4·6 | 1,100<br>1,200<br>1,300<br>1,400 | 13·2<br>14·5<br>15·5<br>16·6 | 0·560<br>0·560<br>0·552<br>0·543 | 14·5<br>15·2<br>17·4<br>18·3 | In wind 65 m.p.h.<br>8·3<br>8·9<br>9·1<br>9·6 | 1·10<br>1·05<br>1·12<br>1·10 |

* Paper read before the Institution of Automobile Engineers, January 29, 1920.

† See Proc. I.A.E., vol. x, page 59.

forms the essential heat flow so far as cooling problems are concerned.

Tests of a water-cooled engine may be carried out either with or without an air blast. In the case of a large multi-cylinder engine an air blast is usual in order to keep the valve springs and exhaust pipe moderately cool and to remove the exhaust gases. In this case, a very appreciable amount of heat is dissipated from the surfaces of the water jackets and crank-case, and the heat actually passing into the jacket water from the working fluid is greater by this amount than that computed from a measurement of the weight and inlet and outlet temperatures of the jacket water. By carrying out duplicate tests with the same wind speed but with different jacket water temperatures, it is, however, possible to determine the heat actually passing through the walls in such a case, and this may be checked by the results of tests with no cooling wind. In the latter case a small experimental correction for radiation from the surface is necessary.

Figures are available from a number of tests on engines of various types, from which these values have been obtained, and the essential data of these tests are given in Table II. For convenience, the heat passing into the walls and piston has been expressed as a fraction of the brake horse-power, 42·42 British thermal units per minute being taken as the equivalent of 1 h.p. The heat passing through the walls is denoted by the symbol A.

6. With the exception of Series 7 and 8, all these tests were carried out under the supervision of the author. The figures of Series 7 are given by the courtesy of Mr. H. Ricardo, from tests made by him. Those of Series 8 are from tests published by Professor Riedler.* Series 1 to 5 were carried out on standard aero engines, and the measurements were made in the course of full-throttle bench tests, with the petrol adjusted to give the weakest maximum load mixture for the particular engine. The values of the heat-loss from the cooling surfaces, given in the penultimate line of Table II, have been computed in every case for a mean jacket water temperature 65 deg. C. above that of the air.

Series 6 was carried out on a single-cylinder Mercedes engine in the course of tests to determine the effect of varying the compression ratio.

The tank engine of Series 7 is fitted with pistons of the crosshead type, and the air passing to the carburettors is circulated around the crosshead guides and under the pistons. During its passage the temperature of the air is raised about 60 deg. F. This degree of air cooling reduces the heat given to the walls. The value of A/B.H.P. deduced from the jacket water measurements alone is 1·01. The absence of this air cooling would bring this value up to 1·05, and an allowance of 5 per cent. for radiation gives the value 1·10 given in Table II. It should be noted that with a crosshead piston the piston friction is reduced, and hence, to some extent, the heat given to the cylinder walls.

In the case of air-cooled cylinders of Series 9 and 10, a complete heat balance was obtained, the exhaust gases being passed through a calorimeter and an analysis being made from which the heat-loss due to unburnt petrol could be obtained. The heat-loss denoted in the last column of the table is obtained by differences from the balance sheet; this includes the heat passing through the walls and piston and dissipated from the surface of the cylinder and crank-case, and carried away by any oil vaporised in the crank-case. The cylinder wall and fin temperatures were measured, and the same cylinders were afterwards erected as radiators in a wind tunnel with circulation of hot water through the barrel, and the actual heat dissipation from their surfaces at the same mean temperature and wind velocity as in the running tests was obtained. These values are given in the penultimate column of Table II. From these figures it appears that of the total heat dissipated from these cylinders, only 53 per cent. in Series 9 and 60 per cent. in Series 10 is actually removed from the cooling surface of the cylinder itself. The remainder, ranging from 49 per cent. to 40 per cent. of the heat equivalent to the brake horse-power is dissipated from the surfaces of the crank-case and by oil vaporised from the lower surface of the piston and walls. These cylinders are lubricated by splash lubrication.

The author would draw special attention to these figures. The amount of heat dissipated from the internal surfaces of a petrol engine depends very greatly on the amount of oil reaching these surfaces. Where the oil supply is only sufficient to give adequate lubrication, this component of the heat dissipation is reduced; more heat must be removed from the outer cooling surfaces, and the cylinder temperature is increased. Variations in the degree of cylinder lubrication readily explain many of the inconsistencies which have been observed in temperature measurements on cylinders otherwise apparently similar.

7. *General Results of Tests.*—The results show that the heat transmitted from the working fluid to the cylinder walls and piston may range from 70 per cent. to 150 per cent. of the heat equivalent of the brake horse-power, depending on the design and conditions of operation of the engine.

8. An examination of Series 1, 2, 3, 6, 8, 9 and 10 shows that under normal conditions of operation and for speeds below that giving maximum power, the speed of the engine has not a large effect on the heat transmitted per brake horse-power. Usually, as in Series 2, 3, 6 and 8, this diminishes with an increase of speed. In Series 1, 9 and 10 the effect of speed is negligible. In general, the diminution in this ratio with increasing speed is more marked in an engine with comparatively low compression ratio.

Table III shows the temperature attained at a point on the side of the combustion space of an aluminium cylinder 4¼-in. bore by 5½-in. stroke, with a compression ratio of 4·7, in a cooling wind of 53·5 m.p.h.

TABLE III.

| Revolutions per Minute. | B.H.P. | Temperature Deg. C. |
|---|---|---|
| 800 .. .. .. .. | 10·2 | 100 |
| 1,000 .. .. .. .. | 12·8 | 103 |
| 1,200 .. .. .. .. | 15·4 | 124 |
| 1,400 .. .. .. .. | 18·0 | 123 |
| 1,600 .. .. .. .. | 19·7 | 136 |
| 1,800 .. .. .. .. | 20·6 | 138 |

The temperature of the cooling wind was 22 deg. C. The tests were carried out at full throttle, with petrol and spark adjusted to give maximum load conditions at all speeds. The normal speed of the engine is 1,400 r.p.m. and the result shows that from 1,200 r.p.m. to 1,800 r.p.m. the effect of speed on the cylinder temperature is very small. If the temperature-difference between the air and the cylinder at the given point be taken as a measure of the heat dissipated from the cooling surfaces, it appears that the heat dissipated per brake horse-power is 13 per cent. less at 1,200 r.p.m. than at 800 r.p.m., and 15 per cent. less at 1,800 r.p.m. than at 1,200 r.p.m.

9. From Series 6, it appears that the heat transmitted per brake horse-power diminishes appreciably with an increase in the compression ratio. Since, within limits, the brake horse-power increases with the compression ratio, the total heat to the walls does not diminish so rapidly as the ratio of A/B.H.P., and may, indeed, increase with an increase in the compression ratio. Tests on any given engine usually show that there is some fairly definite compression ratio giving a minimum wall temperature, and show that for moderate variations of compression ratio on either side of this value, the variation of temperature is small.

The point is brought out by the test figures from an aluminium air-cooled cylinder of 100 mm. bore by 140 mm. stroke, under maximum load conditions in 64-m.p.h. wind, given in Table IV. Attention is drawn to the figures for petrol consumption and brake mean effective pressure in these tests, as indicating the possibilities of such a cylinder.

TABLE IV.

| Compression Ratio. | Brake Mean Effective Pressure. | Petrol, Lb. per B.H.P. per Hour. | Mean Temperature of Barrel, Deg. C. | | Remarks. |
|---|---|---|---|---|---|
| | | | Top. | Bottom. | |
| 4·6 | 116·2 | 0·530 | 180 | 105 | |
| 5·0 | 119·3 | 0·507 | 170 | 95 | |
| 5·4 | 122·0 | 0·490 | 157 | 89 | |
| 5·8 | 125·0 | 0·475 | 154 | 85 | |
| 6·2 | 129·0 | 0·480 | 183 | 110 | Occasional pinking. |
| 6·4 | 123·0 | 0·520 | 212 | 135 | Heavy pinking. |

10. *Effect of Cylinder Dimensions.*—The tests available are not sufficiently comprehensive to enable any decisive opinion to be expressed on the effect of a variation in the cylinder dimensions on the heat transmission per brake horse-power. A comparison of the Fiat and Sunbeam engines (Nos. 3 and 5) which have sensibly the same compression ratio, shows that the ratio A/B.H.P. is 10 per cent. less in the Fiat engine, which has a cylinder diameter of 68 per cent. greater. The comparison is, however, invalidated by the fact that the speed of the Sunbeam engine is 2,100 r.p.m. as compared with 1,250 r.p.m. of the Fiat. At the same speeds it appears probable that the ratio A/B.H.P. would be about 20 per cent. less in the large than in the small cylinder.

If a mean be taken of the values of A/B.H.P. from engines 1, 2 and 4, all of which have roughly the same cylinder diameter and compression ratio, and if this be compared with the value for engine 6 with the same speed and compression ratio, the result shows a mean diminution of 9 per cent. in A/B.H.P. corresponding to an increase of 33 per cent. in cylinder diameter. This question requires much further experimental investigation, but as a temporary working assumption based on these and other results, it may be taken that over the range of normal cylinder sizes each 10 per cent. increase in cylinder diameter in engines of similar design diminishes the heat-loss to the walls per brake horse-power by about 3·5 per cent.

Since, however, in similar air-cooled cylinders at the same speed of rotation, the horse-power is approximately proportional to the cube of the linear dimensions, the ratio of cooling area to heat given to the walls increases as the cylinder diameter is reduced. Taking into account the greater heat transmission per brake horse-power as the cylinder size is reduced, it may be taken as approximately true for similar cylinders and for moderate ranges of diameter, that the temperature difference between an air-cooled cylinder and the cooling air, in a given wind, is inversely proportional to $D^{0.6}$.

11. *Design.*—The influence of design is shown by a comparison of engines 6 and 7, of which the former has overhead valves, and the latter an L-shaped head. Making this approximate allowance for the difference in cylinder diameter, the L-head cylinder transmits approximately 18 per cent. more heat per brake horse-power to the walls than does the overhead valve cylinder. In this L-head cylinder the design is probably as clean as can be obtained with such a type of cylinder. In engine 8, also an L-head engine of smaller size, the exposed combustion space area per unit of cylinder capacity is approximately 25 per cent. greater than in engine 7, while the ratio of A/B.H.P., when approximately corrected for differences in the cylinder sizes, is 20 per cent. greater than in engine 7.

12. *The Strength of the Working Mixture* has a very appreciable effect on the heat transmitted to the cylinder walls. The hottest cylinder is obtained with the weakest mixture capable of maintaining maximum load. This is roughly a 13·5 to 1 air/petrol mixture. Any weakening of this mixture not only reduces the brake horse-power, but also the heat-loss per brake horse-power, and so in a double degree tends to give a cooler cylinder. At the same time it gives an appreciably hotter exhaust, and so tends to cause overheating of the exhaust valves.

These points are well brought out by the figures in Table V, which are taken from tests on an air-cooled aluminium cylinder 100 mm. bore by 140 mm. stroke (engine No. 9).

TABLE V.

| Test. | Revs. per Minute. | B.H.P. | Petrol, Lb. per B.H.P. per Hour. | Air/Petrol Ratio. | Heat Balance Expressed as H.P. | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Unburnt Petrol. | B.H.P. | Exhaust. | From Surface of Cylinder and Crank-case, &c. |
| 1 | 1,800 | 16·2 | 0·544 | 13·6 | 7·80 | 16·2 | 20·3 | 18·3 |
| 2 | 1,800 | 15·1 | 0·516 | 14·9 | 1·64 | 15·1 | 23·3 | 16·0 |
| 3 | 2,000 | 16·1 | 0·535 | 14·0 | 6·07 | 16·1 | 22·0 | 17·2 |
| 4 | 2,000 | 15·3 | 0·523 | 15·0 | 1·00 | 15·3 | 26·1 | 15·8 |

Each pair of tests was run at full throttle under identical conditions except that the petrol supply in 1 and 3 was adjusted to the weakest maximum load mixture, while in 2 and 4 it was still further reduced so as to give approximately the maximum thermal efficiency on the brake horse-power.

TABLE VI.

| Petrol, Lb. per B.H.P. per Hour. | Brake Mean Effective Pressure. | Air/Petrol Ratio. | Exhaust Valve Temperature, Deg C. |
|---|---|---|---|
| 0·622 | 122 | 11·1 | 706 |
| 0·589 | 122 | 11·9 | 717 |
| 0·515 | 119 | 13·8 | 747 |
| 0·480 | 116 | 15·2 | 752 |
| 0·470 | 114 | 15·7 | 747 |

The figures of exhaust valve temperatures in Table VI taken from tests on a similar cylinder, with a compression ratio of 5·5, show that the maximum temperature is attained with an air/petrol ratio of about 15 : 1, and a consumption of 0·490 lb. per brake horse-power per hour, whereas the maximum wall temperature is obtained with an air/petrol ratio of about 13·5.

A further increase in mixture strength beyond that necessary to give full power reduces the temperature of the cylinder surfaces. In this case combustion is very incomplete, the maximum temperature of combustion is diminished, while the evaporation of the unvaporised petrol entering the cylinder is a secondary reason for the reduction of the temperature obtained. This point is well shown by the figures in Table VII, which show the temperatures at the same point, near the centre of the head of an aluminium air-cooled cylinder with overhead valves. The engine was operating at full throttle throughout at 1,400 r.p.m. The only variable in the tests was the petrol supply to the carburettor. The air temperature was 23 deg. C.

TABLE VII.

| Test. | B.H.P. | Petrol, Lb. per B.H.P. per Hour. | Air/Petrol Ratio. | Temperature of Cylinder Head, Deg. C. |
|---|---|---|---|---|
| 1 | 32·8 | 0·70 | 10·5 | 200 |
| 2 | 33·2 | 0·64 | 11·4 | 215 |
| 3 | 33·3 | 0·57 | 12·9 | 237 |
| 4 | 32·9 | 0·54 | 13·5 | 229 |
| 5 | 30·6 | 0·51 | 15·4 | 215 |

13. *The Timing of the Ignition* may have a profound effect on the maximum temperatures obtained, and on the heat dissipated to the walls, mainly because it largely governs the type of combustion. This effect is well shown by the figures in Table VIII, taken from tests on an aluminium-headed air-cooled cylinder, 5¼ in. bore by 6½ in. stroke. In these tests the only variable was the spark advance. The figures show the cylinder wall temperatures at the centre of the combustion head, in an 80-m.p.h. cooling wind, at 1,450 r.p.m.

TABLE VIII.

| B.H.P. | Petrol, Lb. per B.H.P. per Hour. | Spark, Advance, Degrees. | Temperature, Deg. C. | Remarks. |
|---|---|---|---|---|
| 30·5 | 0·515 | 21 | 215 | |
| 31·2 | 0·498 | 26 | 215 | |
| 31·6 | 0·492 | 30 | 221 | |
| 31·6 | 0·492 | 36 | 245 | Occasional pinking. |
| 31·0 | 0·500 | 40 | 275 | Continuous heavy pinking. |

* "The Scientific Determination of the Merits of Automobiles." A. Riedler, The General Oil Publishing Company, Limited, London.

The figures show that so long as the spark advance is not so great as to produce pinking, it has comparatively little effect on the wall temperatures. Once pinking is set up, the temperature shows a very appreciable rise.

14. *Fuels.*—The amount of heat transmitted to the cylinder walls varies somewhat with the composition of the fuel. The author has no evidence to show how it varies with the quality of the petrol, where this is used. A number of tests have, however, been made with petrol-benzol mixtures, with results that show that :—

(*a*) The heat transmitted to the walls per brake horse-power is somewhat less with a 20 per cent. benzol mixture than with standard petrol.

(*b*) The difference increases with the compression ratio.

(*c*) The difference increases with the engine speed.

In the case of the single-cylinder Mercedes engine (No. 6) the difference was :—

1 per cent. with a compression ratio of 4,
2 per cent. with a compression ratio of 5,
3 per cent. with a compression ratio of 6,

at a speed of 1,400 r.p.m.

As the power developed under normal conditions is about 5 per cent. greater with a 20 per cent. benzol mixture than with petrol, the total heat transmitted to the walls is sensibly the same whichever fuel is used.

This is borne out by the results of tests on an aluminium air-cooled cylinder, tested with Shell A petrol and with a mixture of Shell A and 25 per cent. benzol. In this case, the compression ratio was 5. At the same speeds the benzol mixture gave 5·3 per cent. more power with a 2½ per cent. increase in consumption by weight. The maximum cylinder temperatures were, nevertheless, sensibly identical, the difference being less than 5 deg. C. The difference is however, very marked where, owing to insufficient cooling or a very high compression ratio, severe pinking or detonation is caused when working on petrol. The temperature of spontaneous ignition of a petrol-benzol mixture is appreciably higher than that of petrol, and under circumstances in which detonation is severe and overheating occurs with petrol, it is possible to obtain normal operation with normal temperatures if a benzol mixture is used.

15. *Working Temperatures.*—Experiment shows that the maximum temperature of the head of an air-cooled cylinder should not exceed about 270 deg. C. for satisfactory working. With maximum temperatures of 200 deg. to 220 deg. C. results, both as regards petrol consumption and brake mean effective pressure, can be obtained which are quite as good as those from a water-cooled engine of similar design and size. If the temperature exceeds about 280 deg. C., trouble is usually experienced through pre-ignition, and plug trouble become apparent, but this is much more marked on some cylinders than others. Generally speaking, the larger the cylinder, the higher the permissible working temperature. The temperature of the exhaust valve at its hottest point should not exceed about 720 deg. C. In the case of valves not exceeding 1·5 in. in diameter, it is quite possible to keep down this temperature, under favourable conditions, to 650 deg. C.

In a well-designed aluminium cylinder of the overhead valve type operating in a 60-m.p.h. wind, experience shows that a provision of from 0·28 sq. ft. to 0·35 sq. ft. of cooling surface per brake horse-power is adequate to give the required temperatures under normal conditions of operation, the larger area applying to cylinders of about 4 in. bore, and the smaller to cylinders of about 6 in. bore. For steel or cast-iron cylinders with overhead valves, this area should be increased by about 50 per cent., and for L-head cast-iron cylinders by 100 per cent.

Tests with reduced wind speeds show that with a cylinder designed for a given air speed, the temperature increases and the power is diminished as the wind speed is reduced. Also the petrol consumption at maximum load is increased. Experiment shows that the difference of temperature between the hottest point of the cylinder head and the cooling air, under such circumstances, is approximately inversely proportional to $V^{0.4}$. Thus in a given series of tests, a reduction in wind speed from 80 m.p.h. to 40 m.p.h. increased the cylinder temperature from 229 deg. to 296 deg. C., the air temperature being 23 deg. C. The brake mean effective pressure dropped from 116 lb. per square inch to 106 lb. per square inch, and the petrol consumption rose from 0·549 lb. to 0·597 lb. per brake horse-power per hour.

Since the heat dissipation is proportional to the area of the cooling surface if this is equally efficient, and to the 0·73 power of the air velocity, the cooling area per horse-power for a given cylinder temperature should be inversely proportional to $V^{0.73}$. Thus a cylinder designed for a 60-m.p.h. cooling blast will maintain the same temperature in a 30-mile wind, if the cooling surface be made $2^{0.73}$ (= 1·66) times as great.

There are, however, practical difficulties in the way of increasing the cooling area beyond a certain limit, and experience tends to show that a well-designed aluminium air-cooled cylinder of overhead valve type, and of 4 in. diameter, cannot be designed to give its maximum output on a really low petrol consumption in a wind of less velocity than about 50 m.p.h.

With smaller diameters the necessary wind velocity for the same wall temperatures, is less, the necessary velocity being approximately proportional to $D^{0.73} = D^{0.82}$.

Table IX. shows, then, the minimum air velocity necessary for first-class performance of air-cooled cylinders of good design and material, under normal full-throttle conditions.

It is true that cylinders may be successfully operated on considerably lower air speeds, but only with reduced output and on appreciably higher petrol consumptions.

An interesting example may be quoted of an aluminium cylinder in which, after testing, alternate fins were first removed. The cylinder was re-tested, after which the whole of the fins were removed and the cylinder was again tested. The diameter and stroke were 4¼ in. by 5½ in. and the speed 1,800 r.p.m. The results are given in Table X.

Table IX.

| Diameter, In. | Velocity, Miles per Hour. |
|---|---|
| 2 | 30 |
| 3 | 40 |
| 4 | 50 |
| 6 | 70 |
| 8 | 90 |

Table X.

| | | | | |
|---|---|---|---|---|
| Cooling area, sq. ft. (including barrel) | 2·0 | 4·2 | 7·0 | |
| Temperature of cylinder head, deg. C. | 360 | 270 | 220 | 70-m.p.h. wind. |
| | — | 320 | 260 | 45-m.p.h. wind. |
| Brake mean effective pressure | 99 | 108 | 115 | 70-m.p.h. wind. |
| | — | 102 | 109 | 45-m.p.h. wind. |
| Petrol, lb. per b.h.p. per hour | 0·68 | 0·62 | 0·56 | 70-m.p.h. wind. |
| | — | 0·65 | 0·61 | 45-m.p.h. wind. |

For cast-iron L-head cylinders the maximum air blast should be increased by at least 50 per cent.

16. *Temperatures at Part Load.*—So far, the temperatures mentioned have all referred to continuous operation under full throttle. Under the normal operating conditions in automobile work this will seldom be necessary, and it is of interest to note how the working temperatures vary on the throttle. Table XI shows the results of such tests on a 150-h.p. twelve-cylinder cast-iron R.A.F. 4A. air-cooled engine at 1,600 r.p.m.

Table XI.

| B.H.P. | Petrol, Lb. per B.H.P per Hour. | Cylinder Head Temperature, Deg. C. above Air. |
|---|---|---|
| 146·8 | 0·560 | 241 |
| 123·8 | 0·555 | 221 |
| 108·9 | 0·573 | 205 |
| 89·0 | 0·585 | 174 |

17. *Cylinder Materials.*—With cylinders of normal design, the middle portion of the head is the hottest point. The difficulty of keeping it satisfactorily cool is mainly due to the fact that the free air flow is impeded by the inlet and exhaust valve ports and valve gear, and that owing to the presence of these ports it is almost impossible to provide adequate cooling surface at this point. This results in the heat having to travel outwards, to be dissipated mainly from the cooling surface surrounding the combustion head. For a cylinder of given design, it follows that the best material to use, with a view to getting this heat away, is that of highest thermal conductivity. Of the three practical materials for cylinder construction, namely, steel, cast-iron and aluminium, the latter has much the highest conductivity.

18. *Aluminium* for cylinder work is used in the form of a copper-aluminium alloy. Table XII gives a list of alloys which have been tested.

Table XII.

| Designation. | Composition. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cu. | Sn. | Mg. | Zn. | Al. | Ni. | Mn. |
| | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. |
| B 4.. | 7·0 | 1·0 | — | 1·0 | 91·0 | — | — |
| B 12 | 12·0 | — | 1·5 | — | 86·5 | — | — |
| B 17 | 14·0 | — | — | — | 85·0 | — | 1·0 |
| B 18 | 8·0 | 1·5 | — | — | 89·5 | — | 1·0 |
| B 19 | 8·0 | — | — | — | 91·0 | — | 1·0 |
| B 25 | 9·0 | — | — | — | 89·0 | 2·0 | — |
| B 28 | 4·0 | — | 1·5 | — | 92·5 | 2·0 | — |
| L 8.. | 12·0 | — | — | — | 88·0 | — | — |
| L 11 | 7·0 | 1·0 | — | — | 92·0 | — | — |

The high zinc alloys, which are suitable for crank-cases and parts not subject to high pressures and temperatures, have also been tested, but are found to be most unsuitable for cylinder work, since their tensile strength is very low at temperatures exceeding 200 deg. C. The tensile strengths of typical sand castings from these alloys are shown in Table XIII.

Table XIII.

| Alloy. | Tons per Sq. In. | |
|---|---|---|
| | At 250 Deg. C. | At 350 Deg. C. |
| L 11 | 5·5 | 3·0 |
| L 8 .. | 10·5 | 6·0 |
| B 17 | 9·5 | 6·5 |
| B 28 | 11·0 | 5·0 |
| B 25 | 8·5 | 4·5 |

With the exception of the alloys containing manganese, all these alloys have approximately the same thermal conductivity (about 0·38 in. C.G.S. units). The addition of 10 per cent. manganese as in B. 17 reduces the conductivity to about 0·27, but this can be increased to a value approximately the same as that of the other alloys by annealing at about 450 deg. C. for a few hours. The relatively high conductivity of these alloys (0·38 as compared with about 0·12 for steel, or 0·10 for cast-iron) combined with their low specific gravity (about 2·1 as compared with 7·8 for steel) renders them specially valuable for pistons and for the cylinder head castings of air-cooled engines. The light weight enables a piston crown or a cylinder head to be made of comparatively generous thickness without being unduly heavy, and this, combined with the high conductivity, greatly facilitates the transference of heat from the hottest parts to the cooling surfaces.

All the aluminium alloys suffer from the drawback that they "grow" in volume on prolonged heating at the temperatures attained in operation. This "growth" is quite apart from distortion or thermal expansion, and in the case of a piston or cylinder head continues for the first 20 hours to 30 hours of operation, after which it apparently ceases. There is, as yet, insufficient evidence to show which alloys have the minimum "growth," though there is evidence that the presence of zinc as a constituent increases the "growth." In the case of a piston, the "growth" is not in itself sufficiently great to be practically important, and does not in general exceed 1 part in 1,000 on the diameter. Where "growth" and distortion take place in the same direction the net increase may, however, amount to as much as 1 in 250.

Experiment shows, however, that the "growth" in a piston or cylinder head may be forced by a preliminary period of annealing at a temperature of about 400 deg. C. for 5 hours, and as this also eliminates distortion, if it is carried out before the final machining, no further trouble is experienced in operation.

*(To be continued.)*

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Reconstruction Work in France. Motor Haulage.—The Commercial Motor Users' Association has made arrangements with the Department of Overseas Trade, whereby motor haulage contractors who desire to send their motor lorries to the Continent for work in connection with reconstruction may do so without having to deposit cash in respect of the 70 per cent. *ad valorem* Customs duty. The French Director-General of Customs has agreed to accept a written guarantee from the association in respect of such deposit.

An Electric Tamping Machine.—The Kalamazoo Railway Supply Company have brought out a novel tamping machine for consolidating ballast under sleepers. This machine consists of a small enclosed induction motor with a tamping bar fixed to the casing in such a way as to be at the end of the casing and perpendicular to the axis of the rotor. The nose of the tool is set so as to incline under the motor, in the same vertical plane as the spindle. Fixed to the opposite end of the casing is an extension of a Z-shaped spring handle. The motor is three-phase 60-cycles and 110 volts, running at 3,600 r.p.m. The spindle is fitted with an unbalanced weight, which sets up an oscillation on the spring handle and gives the necessary motion and kick to the tamping bar. The amplitude of the movement is stated to be ¼ in., which can be varied to suit the ballast, by changing the tamping bar for one of a different weight. It is said that if the tamping bar is placed against a sleeper in ordinary ballast, the tool will work its way down the side and under the sleeper. The operator merely has to hold the machine upright and direct it to its work. The machine is watertight and dust-proof, and weighs 37 lb. It is arranged for working four machines from a small portable electric generating set weighing 125 lb., so that the whole outfit is quite of a portable nature. Smaller and larger sets are also supplied.

Sulphur in Benzole.—At the request of the National Council of the Commercial Motor Users' Association (Incorporated), the Petroleum Executive and the Aeronautical Inspection Department last year undertook to make certain investigations as to the effect of sulphur in benzole on various metals. The specification of the National Benzole Association fixes 0·4 per cent. of sulphur as the maximum. The association has received the results of this investigation and the permission of Sir John Cadman, K.C.M.G., to publish the report as follows: "Four samples of benzole were supplied, stated to contain 0·1 per cent., 0·2 per cent., 0·4 per cent. and 0·8 per cent. sulphur respectively. Chemical examination of these showed that the sulphur was nearly all present as carbon bisulphide, not more than one-sixth being present as thiophene. The metals used were: Copper, brass, phosphor-bronze, aluminium, cast-iron. After prolonged contact with benzole containing 0·8 per cent. combined sulphur, a slight discoloration of the surface was obtained with copper and brass. In the presence of moist air, also, slight action appears to take place, but no measurable difference occurred in the weights of the metals before and after the action. Under these circumstances, quantitative figures for the corrosion effects cannot be given. The iron and steel rusted in the moist air, but there was no evidence of the formation of any oxidation products of sulphur. There is little doubt that the same effect will occur with the vapours of the other benzoles, although, of course, after a longer period. In view of these results, as no corrosion occurred, the answer to the questions as to whether corrosion had in any case reached the degree of perforation of a sheet of metal is in the negative. A sample of the deposit found in carburettors of aero engines was found to consist of a greyish-white powder decidedly alkaline to litmus, and containing metallic particles. The metallic particles consisted of aluminium with traces of zinc, copper and iron. The remainder of the deposit was sodium silicate with traces of carbonate and sulphide, the latter being probably impurities present in the sodium silicate used for 'doping' the carburettors. There is therefore no evidence that the sulphur content of benzole has any corrosive effect on carburettors."

## THE GERMAN ELECTRICAL INDUSTRY.

ALTHOUGH the Siemens and Halske Company has declared a dividend of 12 per cent. for last year, the present position and the future outlook of the company are somewhat gloomy. The past year has been a difficult one, and the prospects for the industry seem to indicate that conditions will tend to become worse. The future of Germany hangs on the question as to whether production, which has been so lamentably short of late years, can be raised again to its old level. Industrial peace and rational labour conditions are the first and most vital considerations.

The money turnover of the industry increased during the year, but this was due to the deterioration of the value of the mark, and not to increased production, and this deterioration arose from the urgent need of Germany and of the rest of the world for goods. There seems, however, to be no possibility of this need being satisfied owing to the ever-increasing cost of production. An instance of this occurs in connection with several transport concerns, where the effect of an increased tariff was merely to reduce the traffic, without increasing the total receipts. The same effect is likely to occur in the electrical industry, since the cost of production will go on increasing. It has often been said, that the industry was dependent on foreign countries, and that it would soon revive, when the necessary foreign materials were again available. This might be true of certain industries, but to many others it does not apply; and the decrease in production is just as pronounced in the latter as in the former. In the first place there is a serious shortage of coal, not because of that supplied to the allies, but because the present production is so much lower than that of pre-war times and also on account of inadequate transport and the consequent inefficient distribution. For the recovery of the industry adequate supplies of coal and iron are of the utmost importance. Shortage of foreign raw materials does not exist at the moment, but there is a serious shortage of German and foreign manufactured products, and also of half-finished products. The labour situation is also serious. Of the possible number of hours that could be worked under the 8-hours' agreement, only about 70 per cent. had been actually put in. Moreover, the output per hour is less than in pre-war times. It may therefore be asserted, that the production of the Siemens Company during last year, based on the quantity of goods turned out, has been only half of what it was before the war. The introduction of politics into labour affairs has not only reduced the output of the men and officials, but the productive capacity of the managerial staff has been greatly interfered with owing to the fact that their time has been so largely occupied with endless negotiations, both inside and outside the works. The German electrical industry would welcome any legislation tending towards industrial peace, and would willingly grant the men diverse concessions, if thereby an assurance of stable and guaranteed production could be obtained. The employers fear, however, that the Works Councils Act, which has recently come into operation, will only lead to further strife.

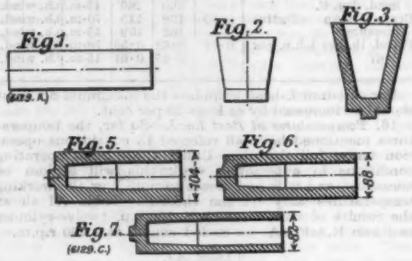
A combine of the three largest German incandescent lamp concerns has been brought about in the new year. The Siemens Company has entered the combine, because the Board thought the position of the German incandescent lamp industry would be strengthened by this arrangement. A systematic subdivision of the manufacture and the advantage of mutual experiences should improve the quality, and lower the cost of production.

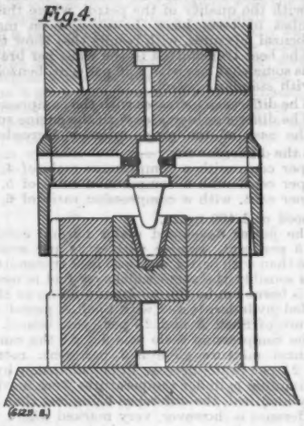
## LOCOMOTIVE USED AS A SHELL PRESS.

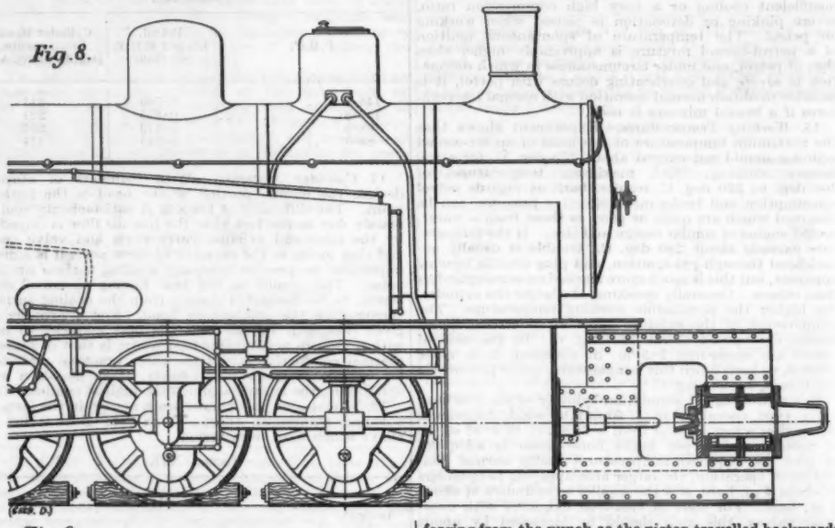
THE proceedings of the Société des Ingénieurs Civils de France for July to September, 1919, contain the account of a very ingenious device used for drawing down 75-mm. steel shells during the war. The account is written by Mr. Szersnovicz, who states that the Bordeaux works of the South of France Railway Company, like all other works in France, were called upon at the outbreak of war to contribute material for the defence of the nation. Their machine tools were immediately requisitioned for the manufacture of fuses and the machining of projectiles received from the arsenal of Tarbes. At the same time the Bordeaux works proceeded to enlarge their plant and they gradually increased their output of munitions of all kinds. In view of the urgent demand for larger quantities of 75-mm. shells they adapted a portion of their machinery to the making of these also, starting from steel bars cut to length, as shown in Fig. 1. These were up et hot in a die and given the shape shown in Fig. 2, the only steam hammer which they could set apart for this work being one of 1,000 kg. The piece, Fig. 2, was then given the cup-shape shown in Fig. 3, this intricate part of the process being carried out in the punch and die system shown in Fig. 4, which was placed on the anvil of the works' 3,600-kg. steam hammer, three or four blows being required for the operation.

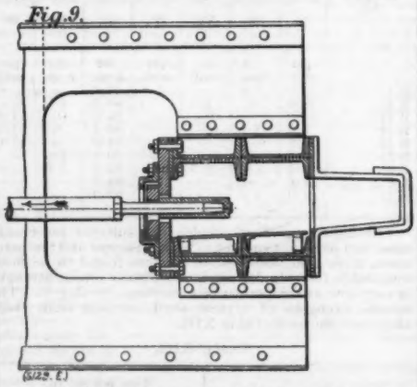
The cup thus obtained had to be drawn down to the cylindrical shapes shown in Figs. 5 to 7, and for this, the Bordeaux works of the Midi Railway had no machine available. Considering the time it would have taken to build, or to await the delivery of a hydraulic press for the purpose, they looked round for temporary means of increasin the shell supply. At first it was thought that the drawing down operations might be done in a spring-testing machine, but it was soon realised that this machine was unable to give the required 80-ton to 100-ton pressure. Attention was then turned to powerful modern locomotive engines built for service on heavy gradients, one of which happened to be lying idle pending repairs. A trial was rapidly prepared, for which the locomotive was moved to a position in front of a stout wall on which the drawing-down die-holder was supported. The locomotive was then raised so that the wheels were clear of the rails, and a punch was fitted to the tail rod of one of the pistons. A cup was then heated to a red heat and placed in the die, when the opening of the regulator-valve drove the punch forward and caused the cup to pass through the die. The test being successful, it only remained necessary to make the installation more convenient for use.

The manner in which this was accomplished is shown in Fig. 8 and to a larger scale in Fig. 9. The buffer beam of the engine was replaced by a much stronger one, built up of plates and sections, and fitted, in front of the cylinder utilised for the drawing-down operations, with the die-holder, a kind of casing open at the side for inserting the dies one after the other. A catch against which the die buts horizontally when it is inserted fixes it in a suitable position so that the axis




of the die is on the same vertical plane as the axis of the piston, the die being, further, supported on the lower part of the casing in such a way that its axis was from 3 mm. to 4 mm. (0·118 in. to 0·157 in.) lower than the piston axis, as shown in Fig. 9.

The cups were heated in a reverberatory furnace erected close to the locomotive. On leaving the furnace, the base of the cup was slightly cooled by immersion to a depth of from 2 cm. to 3 cm. (0·787 in. to 1·181 in.) in a tank of water maintained at a constant level. At the same time, the bottom of the cup was freed of scale by means of a kind of milling cutter worked by a small portable drilling machine driven by compressed air, suspended from a jib and maintained at the right level by a counterweight. The cup cooling was so devised as not to water-harden the metal; it imparted to it sufficient resistance to prevent the punch from driving through the base of the cup. While the cup was being made ready, the man in charge of the punching inserted the larger die after having greased it; his assistant then placed the base of the cup in the die, the regulator valve was opened and the punch drove the cup through the die. As soon as the forging had been driven through, the die, which in the process, had been raised and placed exactly in the axis of the cylinder, fell back in its seating and constituted a stop which helped to strip the forging from the punch as the piston travelled backwards. The forging then fell on a gutter plate, whence it was removed and replaced on the punch when the piston was in the rear position. During the time occupied in this the man in charge of the punching operations replaced the first die by a smaller second one, when the drawing down continued in practically the same way, the second die acting also for stripping the forging from the punch. The third pass proceeded in a similar manner, but before this, the forging was slightly reheated. During the drawing down operations, the punch was cooled by water jets and the dies were freed of scale, cleaned, greased and placed in order for each successive operation.

Besides the regulator-valve handle, the engine driver had within easy reach an air-brake valve which was used to brake the driving wheels at the end of each revolution and to stop the crank on the rear dead-centre. As soon as the forging had been driven through the die, and although the regulator-valve was immediately closed, the inertia of the driving wheels frequently resulted in two or three revolutions at comparatively high speed before the piston could be stopped at the back end of its travel. This resulted in somewhat heavy jerks which shook the wheel scotches; it sufficed, however, to inspect the position of the scotches every morning and to strengthen them where this was found to be necessary.

The installation ran successfully for about two years at the Bordeaux works of the Midi Railway Company, and produced several hundred thousands of 75 mm. shells, pending the putting down of a more suitable hydraulic plant. It enabled the works, from the very commencement of the war, to do away with the manufacture of shells by boring out of the solid, thus saving a large quantity of metal, and much time, and making the machine tools which would thus be utilised available for other pressing munitions work.

MIDDLESBROUGH PIG-IRON SHIPMENTS.—The statement issued on January 31, by Messrs. William Jacks and Co., 5, East India-avenue, E.C., shows the shipments of pig-iron from Middlesbrough and Skinningrove to have been in January 6,835 tons coastwise and 31,543 tons foreign, a total of 38,378 tons, as compared with 35,572 tons in December, 31,381 tons in January, 1919, and 31,022 tons in January, 1918.

# ELECTRIC DRIVE FOR ROLLING MILL FOR LEAD SHEETS.

## CONSTRUCTED BY METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, TRAFFORD PARK, MANCHESTER.

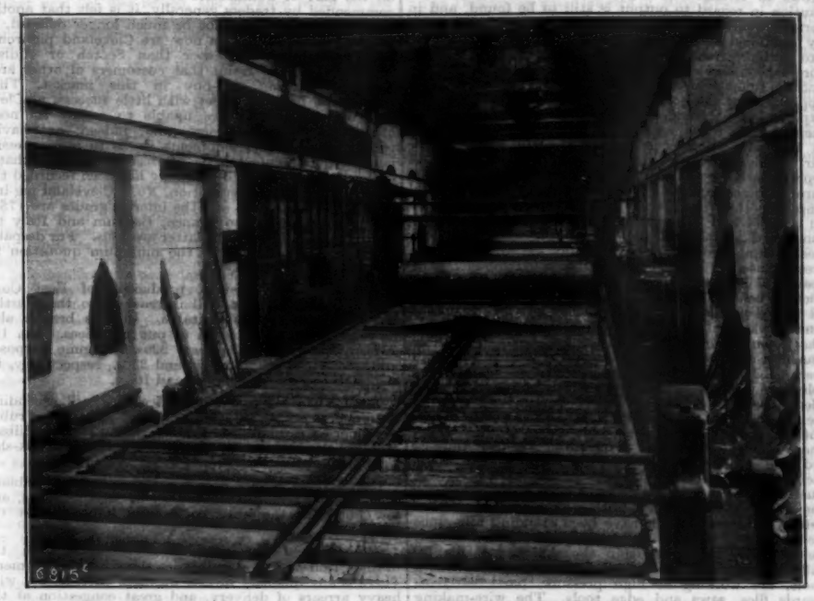


FIG. 1. THE ROLLING MILL.

FIG. 2. THE WARD-LEONARD CONTROLLER.

IT was recently decided to convert a lead sheet rolling mill at the works of Messrs. Holman, Mitchell and Co., Limited, St. Helens, from steam drive, involving a separate small boiler and engine, to electric drive. The mill has rolls 9 ft. long by 23 in. in diameter, and is fitted with hand-operated screw-down gear. It has two sets of live rolls, three rolls to each set, driven by the rolling mill motor through gearing. The conversion from steam to electric drive was carried out by the Metropolitan Vickers Electrical Company, Limited, and the new equipment consists of a 90-h.p. mill motor, a 75-kw. motor generator consists of a 90-h.p. mill motor, a 75-kw. motor generator set with 2-ton flywheel and the necessary Ward-Leonard control gear. This system was adopted in preference to the single machine drive with reduction gear, and reversing by means of a reversing controller of the contactor or drum type, or reversing by means of reversing gear and friction clutches.

The mill was designed to roll ingots approximately 9 ft. by 8 ft. by 6 in. down to 1-in. slab, in 130 passes, in 25 minutes; the equipment deals with this easily. A general view of it is shown in Fig. 1, above. The mill motor, shown in Fig. 3, page 218, is rated at 90 hp.r.m.s. Although designed for a peak of twice full-load torque, it will take loads considerably in excess of that figure without injurious sparking. Arranged to run at 120 r.p.m. the motor drives the mill shaft through straight-toothed gearing having a ratio of 4½ to 1, the mill running at 26·5 r.p.m. The motor is of the plain shunt-wound type, and is fitted with interpoles. Special precautions were taken with regard to the armature coils, to ensure that the moderate shocks due to the gearing would do no injury to the windings.

The equalised Ward-Leonard motor generator set is illustrated in Fig. 4, page 218, and consists of a 100-h.p., 550-volt direct-current compound motor, which takes power from a feeder bus-bar of the local tramway supply. This motor is mounted on the same bedplate as the 75-kw. generator, as is also a 2-ton cast steel flywheel, 7 ft. 9 in. diameter, running at 780 r.p.m. The stored energy in the flywheel is utilised during each pass, through the drop in speed of the motor generator set due to the compound winding on the driving motor. A friction clutch is introduced between the flywheel shaft and generator in order that the wheel may be shut down when the mill is on light work.

The Ward-Leonard controller, Fig. 2, above, designed for use with this equipment, differs somewhat from the usual small face-plate type. It consists of a contactor panel and master controller, the latter being attached to the operator's lever by means of a crank and rod. As the master controller is moved over, the relays cut out the resistances in the generator field in six steps, one by one, no accelerating relays being required. The arrangement of connections is such, that should the lever be moved to the full "on" or "off" position as rapidly as possible, the contactors can operate only in their proper sequence.

In order to speed up the building of the generator field, which normally would take an appreciable length of time because of its opposing inductance, a certain amount of "forcing" is used. This is effected by designing the field for a voltage lower than the available exciter voltage and arranging a non-inductive permanent resistance in the generator field. The initial voltage across the field terminals is thus high, dropping to normal when it has established full field current. For instance, on a certain machine with fields arranged for half exciter volts and permanent resistance proportioned to take up half voltage at full field current, the period required for building up the field was reduced from 5·5 seconds normal to 2 seconds.

The energy expended in breaking down warm lead ingots is about one-sixth of that required to roll mild steel ingots in a cogging mill at the usual temperatures. The energy required per pass gets less as the lead ingot is rolled warmer, and, it is said, the rolled product is mechanically sounder when greater draughts are taken. In the case of this mill the ingots are usually rolled at an initial temperature of approximately 80 deg. C., the final temperature, after reduction to 1 in. thickness, being approximately 60 deg. C.

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CAUSE OF THE SHARP BOUNDARY OF THE SOLAR DISC.—The sun appears to us like a luminous disc with a sharply-defined boundary. If we could fly into the sun, however, the boundary would probably become hazy as we approached the sun, and we could, in a sense, no more tell the moment of our entering the sun, than a wanderer can say exactly when he is actually entering the forest that he had seen before him. That is not the argument, however, which C. G. Abbot adopts in writing on the "Cause of the Apparent Sharp Boundary of the Sun" in *The Astrophysical Journal* of November last. His previously-expressed views on the subject had been criticised by J. Spijkerboer, W. H. Julius and B. J. van der Plaats in the *Archives Néerlandaises*, and he points out that, owing to molecular scattering and true absorption by the gases, radiation cannot travel more than 7,000 km. in the outer layers of the sun immediately beneath the chromosphere. Outside the chromosphere the gaseous density is so small that neither by radiation, nor by scattering is the brightness comparable with that of our atmosphere near the sun. Parts below a depth of 7,000 km. furnish us no rays at all, and as a source of radiation, the sun may therefore be regarded as a hollow shell, which will be thicker for long waves than for short waves, and thicker also at the centre of the disc than at the limb. For, owing to obliquity of the line of sight, the rays traversing 7,000 km. lie near the surface of the limb and are probably confined there within a layer less than 1 second of arc or 725 km. in thickness. Hence the appearance of a sharp disc.

SHIPBUILDING IN SWEDEN.—We read in *Swedish Export* that the largest Swedish shipyards are overwhelmed with orders. Lindholmen is full up for a couple of years already, and Götaverken for as long as five or six years. The prices are about the same as in England, or between 650 kroner and 800 kroner per ton deadweight for cargo vessels of ordinary size, varying with the equipment. At the other shipyards, it would seem that a certain amount of orders can still be accepted.

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THE ATTRITION OF CONCRETE SURFACES EXPOSED TO SEA ACTION.—In a paper by Mr. J. S. Owens read before the Concrete Institute on January 22, on the "Attrition of Concrete Surfaces exposed to Sea Action," the author states that wear cannot be avoided, and all that can be done therefore is to reduce its rate. The problem can be dealt with in three ways. In the first the object aimed at is to increase the resistance of the surface to attack. This has been mainly attained by using as large particles of aggregate as possible for the facework. In the second the attempt is made to mitigate the severity of the attack. This may be accomplished by protecting by groyning, or even dumping small shingle on areas where the size nominally on the beach is large. Some attempt has been made to protect a wall face by wooden blocks placed end on, providing a renewable coating. This almost comes within the third system, which makes the wall in such a form that its face can be renewed. This has been done by the author by arranging for a renewable face, 2 ft. thick. When renewing this, large flints are arranged near the face. After removing the shuttering the smooth concrete breaks away, exposing the flints, after which the rate of attrition is much reduced.

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LEAD ATTACK BY SULPHURIC ACID.—The demand for sheet lead and lead piping was one of the many which increased largely during the war. In genera , the purest lead is believed to answer best as material for the concentration pans of sulphuric acid. A certain small percentage of copper is, however regarded as beneficial, and this is confirmed by some tests which were communicated in December last to the London Section of the Society of Chemical Industry by Mr. C. E. Barrs. He found that two leads, both of high purity, the one containing 0·002 per cent., the other 0·021 per cent. of copper, otherwise very similar in composition, behaved differently in hot sulphuric acid; the former was vigorously attacked by the acid at 250 deg. C., whilst the latter resisted the acid until a temperature of 296 deg. C. was reached. This observation was subsequently confirmed by experiments in which he added 0·2 per cent. of various elements, copper, bismuth, arsenic, antimony, zinc, tin, silver, tellurium, sulphur, to the copper; copper, silver and arsenic decidedly raised the resistibility of the lead, whilst bismuth and sulphur lowered it. Antimony had in this small proportion little effect; large percentages of antimony make lead harder, of course, but such lead is rarely exposed to high temperatures. It should be noted, though it was not mentioned during the discussion, that the lead percentage was simply determined by difference. A large mistake could hardly be made by not checking the analytical results by the quantitative determination of the chief constituent, lead, but one does not know, and the practice is not recommendable.

## PROPERTIES OF GLUES.

Report No. 66 of the United States Advisory Committee for Aeronautics is devoted to the subject of glues used in aircraft manufacture, and, as a result of a series of experimental and other investigations, it sums up the properties of five different types of glue as follows: Animal glue, the properties of which are familiar to woodworkers, is used as a standard for comparing the other varieties. The higher grades of animal glue possess great strength and reliability, and, in general, glue of this type flows freely and does not strain fancy veneers. No other glue is considered to be equally satisfactory for hand-spreading on irregularly-shaped objects. The chief features limiting its use are its high price and the fact that it is not very resistant to water. Casein glue is of comparatively recent introduction. Its strength is equal to that of medium grade animal glues; it is used cold and can be applied with a brush, but its most valuable feature is its high water-resisting property. On the other hand, casein glues have a tendency to stain thin veneers, and, in some varieties, the working life is relatively short. Vegetable glues have been widely used in recent years on account of their low cost. They are used cold and remain in good working condition, without decomposition, for many days, but they are too viscous to spread by hand and are not water resistant; they also have a tendency to stain thin fancy veneers. Blood albumin glue has shown high resistance to water, especially in the boiling test. This property makes it suitable for the manufacture of plywood, which is intended to be softened in water and moulded to shape. It is possible to make very cheap blood glues for the production of medium or low-grade articles, and it can also be made in the form of a dry tissue, the glueing then being effected in a hot press. In this form it would appear to be very useful for laying fancy veneers since the troubles due to moisture changes usually experienced would be avoided. The disadvantages in connection with the use of blood glues are the expensive apparatus required, the relatively low production of the presses, and the fact that they are only suitable for glueing comparatively thin pieces. In strength, blood glues are about the same as vegetable glues, and both varieties are approximately the same as, or, if anything, slightly weaker than, medium grade animal glues. The properties of liquid glues are, in general, similar to those of animal glues, and some brands give joints of equal strength. Their great advantage is that they are purchased in prepared form ready for immediate use, and this feature renders them very convenient for small jobs. Liquid glues, however, are expensive, and this fact, together with their poor water-resisting properties, tends to limit their use. Another drawback is the difficulty the user has of distinguishing between good and bad brands, the latter being very weak and unreliable. Altogether it appears from the foregoing notes that none of the glues referred to is so far superior to the others as to be suitable for universal application. Evidently the properties of each variety must be considered in relation to the purpose for which it is to be employed. Further information as to the sources, properties, methods of manufacture, methods of applying, and methods of testing the glues above referred to is given in the report which is entitled, "Glues Used in Airplane Parts," and can be obtained on request from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

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The Agricultural and General Engineers, Limited.—Following our announcements in our last volume, the other firms about to be associated under the A.G.E. are: Messrs. Barford and Perkins, Limited; Messrs. Charles Burrell and Sons, Limited; Messrs. Clarke's Crank and Forge Company, Limited; and Messrs. E. R. and F. Turner, Limited. Negotiations are pending in respect to three other considerable firms, well known in the agricultural engineering world, joining the combine. The central organisation offices will be established at Central House, Kingsway, on March 15, and these offices will be retained until the company's offices on the Aldwych site, to be called "Aldwych House," are completed.

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The "Fullagar."—On Thursday, the 5th inst., the ship Fullagar was launched from Messrs. Cammell Laird's works at Birkenhead. Her propelling machinery is of the new opposed piston type of internal-combustion motor known as the "Cammellaird-Fullagar" engine, while in the construction of her hull riveting has been dispensed with, all connections being made by electric welding on the "Quasi Arc" system. The new engine which is to be subjected to a long and exhaustive series of trial trips on coasting routes, by her owners, Messrs. T. and J. Brocklebank, Limited, Liverpool, has recently been fully described in Engineering. The ship is a 500-ton coaster, and her construction marks the issue of a long series of experiments with a view to the adaptation of electric welding to the building of ships' hulls which have been carried out during the past year or two under the supervision of "Lloyd's Register of Shipping." The society has given the vessel experimental classification in its register. Much information has been gained regarding the tensile strength and elastic properties of welded metal and its behaviour under alternating stresses, and this development will be of the greatest service in the further application of electric welding to both the construction and repair of ships. With the help of the older process, namely, oxy-acetylene welding, a great deal of valuable tonnage has been quickly restored to service after sustaining severe hull or machinery damage.

## NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

*Iron and Steel.*—The engineering trades are fully employed trying to make up for lost time. Heavy arrears have to be wiped off, and in addition the current demand grows in strength weekly. Evidence of trade union caution in regard to output is still to be found, and in certain quarters is causing a good deal of complaint by manufacturers whose chief anxiety is to expedite production. Generally speaking, however, the moulders, coremakers, and steel smelters are working satisfactorily, and the tonnage of castings leaving most of the foundries approximates the normal average. The chief difficulty experienced by engineering organisers is in getting the men to work overtime and to take a practical interest in the completion of contracts specially required for early delivery. Apart from this, it is the opinion of representative manufacturers that output is slowly but surely increasing. It is generally conceded among employers that the question of the training of apprentices on a wider and more productive basis will have to be considered seriously if the quality of engineering and steel-making products is to be fully maintained. The present need is chiefly for highly-skilled labour. The dearth of such labour is without doubt keeping production below the level of current requirements. For all classes of mild steel, pressure continues great, and the tendency is for arrears to increase rather than to diminish. The execution of orders continues to be hampered by transport delays and the shortage of wagon facilities, and there is also a considerable difficulty in maintaining deliveries of raw and semi-finished materials on an adequate scale. After a period of comparative depression the crucible steel trade shows welcome signs of recovery. Both on home and export account orders are increasing. There is a ready demand from Italy, France, America and the Colonies. The condition of the American exchange is enabling Sheffield producers to recover much trade that was lost or suspended during the war. The call for electric steel is such that several firms have restarted furnaces which have been standing idle since the armistice. Orders, particularly on export account, are plentiful, and here again the shortage of highly-skilled labour is apparent. The tool trades, taken as a whole, are working at high pressure, particularly as regards files, saws and edge tools. The wire-making works are booked up for six months ahead. There is no change in quotations for raw and semi-finished materials, though further advances are not improbable in the near future. The market for ferro-alloys is improving now that the large stocks left at works from war-time purchases are nearing exhaustion.

*South Yorkshire Coal Trade.*—The demand exceeds the supply for practically all classes of fuels. The output of manufacturing qualities appears to be less satisfactory. In some cases large fuel-consuming works have been obliged to draw on their reserves to augment current deliveries. A big tonnage is going inland for railways and blast furnaces. A very restricted export trade is being done at highly remunerative prices. There is no improvement in the house-coal section. The whole output is either going away on contract or is under allocation by the Coal Controller's Department. The market in coke is exceptionally strong for all qualities. Quotations:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

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Higher Railway Rates in Germany.—The German railway rates will be raised again on March 1, the increase amounting to 100 per cent. for goods and live animals. For passengers it is likely to be about the same, though at one time a rise of only 50 per cent. was expected. The agreement recently entered into with the railway men, involves an additional expenditure of 1,500,000,000 marks per annum.

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Milan Trade Fair.—The British Italian Corporation, Limited, 12, Nicholas-lane, E.C. 4, informs us that the Milan Trade Samples Fair is to open on April 12, not April 1, as stated on page 107 *ante*, the number of stands reserved for British exhibitors being 60, the figure given in our paragraph on page 48 *ante*. The corporation has now issued an abstract of the regulations, giving the charges for rent of stands and open sheds, and further information for the use of exhibitors. Exhibits will be grouped by category of goods, not by nationality of exhibitors.

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Increase of Capital in German Industries.—The tendency on the part of German industrial concerns greatly to increase their capital continues on an extensive scale. Thus the Leopold Cassella Company, of Frankfort, has issued ordinary shares for 30,000,000 marks and preference shares for 32,000,000 marks. The company's capital now amounts to 194,000,000 marks. The Lech Electric Company, of Augsburg, in increasing its capital from 18,000,000 marks to 30,000,000 marks, but this does not cover the company's financial needs; the remainder will be raised through bank credits. The Company for Insulated Electric Wires, which has just declared a dividend of 18 per cent., has raised its capital from 7,500,000 marks to 11,500,000 marks, and appears to have obtained sufficient orders for the current year. The Continental Caoutchouc and Guttapercha Company, of Hannover, is about to increase its capital by 30,000,000 marks in ordinary shares, and by 10 000,000 marks in preference shares.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

*Cleveland Iron Trade.*—The anticipated rise in Cleveland pig-iron has not occurred, and wh lst the reluctance on the part of ironmasters to advance rates further is commended by traders generally, it is felt that another upward movement cannot be much longer delayed, for unprecedented as figures now are Cleveland pig-iron is still comparatively cheaper than Scotch or Midland pig-iron, with the result that customers of other areas are endeavouring to buy in this market. These purchasers, however, meet with little success, as Cleveland pig-iron makers are unable to satisfy the needs of their regular customers, and, indeed, are having ruthlessly to curtail shipments so as to meet pressing home requirements. It is interesting to note that a shipment of 200 tons to Germany has been recorded this week. For home consumption, No. 1 Cleveland pig-iron is 162*s.* 6*d.* and No. 3 and the inferior grades are 175*s.*; whilst for shipment to France, Belgium and Italy the former is 187*s.* 6*d.* and the latter are 180*s.* For despatch to other foreign countries the minimum quotation for Cleveland pig-iron is 230*s.*

*Hematite Iron.*—Cost of production of East Coast hematite is high, and still increasing, so that further rise in prices seems inevitable. In this branch also, however, makers are loath to put up prices. No. 1 is 222*s.* 6*d.* and mixed Nos. are 220*s.* for home purposes, and quotations are 232*s.* 6*d.* and 230*s.*, respectively, for despatch to France, Belgium and Italy.

*Foreign Ore.*—Foreign ore prices are still ascending. As much as 50*s.* is reported to have been paid for rubio, of 50 per cent. quality on the 17*s.* parity freight, Bilbao-Middlesbrough, and as the freight is now 34*s.*, the ex-ship Tees price of best rubio must be given as 67*s.*

*Coke.*—Coke is very scarce and firm. Average blast-furnace kind readily realises 50*s.* 6*d.* at the ovens, and low phosphorus quality commands fully 53*s.* at the ovens.

*Manufactured Iron and Steel.*—Conditions in the finished iron and steel industries show no improvement. There is any quantity of new business offering, but with heavy arrears of delivery, and great congestion at the works, producers are unable to entertain it. Manufacturers, indeed, are quite unable to cope with the work they have in hand, and the already heavy stocks, due to continued lack of means of distribution, are still accumulating. Some firms are reluctantly compelled to work short time because of delay in clearing away output, and, of course, the present situation renders it quite impracticable to put new plant, that has been laid down, into operation. Prices all round are very strong, and quotations of steel plates, angles and joists are up 20*s.* Common iron bars are 24*l.*; marked bars, 26*l.*; steel ship, bridge and tank plates, 21*l.*; steel boiler plates, 24*l.*; steel angles, 20*l.* 10*s.*; steel joists, 20*l.* 10*s.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; steel billets, 19*l.* to 20*l.*; heavy sections of steel rails, 18*l.* 15*s.*; and fish plates and sleepers, 23*l.* 15*s.*

*Railway Rates.*—A good deal of adverse criticism is heard with regard to railway rates. For many years it has been the practice in this district to regulate railway rates for minerals by the selling price of pig-iron and under this system the sliding scale had, prior to January 15, given a rise in railway rates of 13 per cent. With the extra rates now in force, under the national revision of railway charges, it is considered the 13 per cent. should be merged in the general advance, and protest is being entered against what is declared to be the unfair attitude of the railway company in charging the new freight rate on minerals, plus the 13 per cent.

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Oil Fuel on Ships and Fire Prevention.—The Board of Trade has appointed a committee under the chairmanship of Sir Thomas Bell, K.B.E., to advise what conditions should be complied with in order to prevent danger of fire, including fire resulting from collision, in the case of passenger ships burning oil fuel, and what special precautions, if any are necessary in the case of oil fuel with a flash-point as low as 150 deg. F. The secretary to the committee is Mr. G. C. Ager, of the Board of Trade, and any communications with regard to the work of the committee should be addressed to him at the Board of Trade, Great George-street, Westminster, S.W. 1.

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Contracts.—Erith's Engineering Company, Limited, 70, Gracechurch-street, London, are furnishing to the orders of the Edinburgh Corporation, Erith-Riley stokers, which are claimed to be much larger than any stokers hitherto made, each stoker being no less than 33 ft. wide. They are also furnishing identical stokers to the Shanghai Electricity Works, each stoker being assembled from standardised, uniform, self-cleaning retort units, set side by side in a straight-walled furnace, under watertube boilers normally evaporating 80,000 lb. high-pressure superheated steam per hour. The coal is fed, the fires are sliced and the incombustible ash is continuously discharged, without manual labour. A battery of 12 Lancashire boilers need eight firemen per shift, for the same steaming duty, hence there is a large saving in labour. The completely automatic Erith-Riley stoker with the modern water-tube boiler gives a thermal efficiency representing, further, a substantial fuel saving, as well as a capacity to use low-grade small fuels to the best advantage. Many important repeat orders are in hand for home, Indian and Colonial electricity generating stations.

## NOTES FROM THE NORTH.

GLASGOW, Wednesday.

*Scotch Steel Trade.*—Very active conditions continue to rule in the Scotch steel trade, and thus one week is very similar to another, the only variation of note being the ever-increasing scale of prices. On Monday of this week another new list was issued, the advance being 1*l.* per ton, which the Scotch steel-makers have found necessary owing to the rising cost of manufacture. The high price to which material of all kinds has gone is really alarming, and there seems to be no finality to it all. Some time ago it was hinted in some quarters that top level had been reached, but prices all round keep advancing and it is difficult to form any idea what the maximum will ultimately be. The demand for plates is as heavy as ever, and consumers keep pressing for deliveries, and while there is more sectional material available the outlet is again better. There is no falling-off in the demand for black steel sheets, and makers are turning out a large tonnage, but everything produced is quickly taken up, and this state will continue for some time to come. A fair business is going through in galvanised sheets. Many inquiries for general material both for home and export—are in the market, but few or no new orders can be considered for near date delivery. In the case of export business only a moderate trade is passing. The prices now fixed by the associated makers for home delivery are as follow:—Ship plates, ¼ in. and upwards, 22*l.* per ton; ship plates, under ¼ in. down to and including ⅛ in., 26*l.* 5*s.* per ton; ship plates, under ⅛ in. down to and including ¼ in., 27*l.* 15*s.* per ton; angles, &c., 21*l.* 10*s.* per ton; boiler plates, 26*l.* 10*s.* per ton; all net and subject to existing extras and conditions.

*Malleable Iron Trade.*—The malleable iron makers in the West of Scotland report no change in the state of the trade, and that the demand for bars is as great as ever. Notwithstanding the present high price of 24*l.* per ton in Glasgow, buyers keep up a constant pressure for deliveries and the actual consumption is considerable. The output is large, but no matter how much is turned out there are demands for more. The export side of the business continues on a small scale, and the minimum price is now 24*l.* 10*s.* per ton, net, f.o.b. Glasgow. Prices are meantime unchanged, but are very firm and are tending upwards.

*Scotch Pig-Iron Trade.*—As in the allied industries the Scotch pig-iron makers find no difficulty in disposing of their outputs at the present time, and in reality the demand is greater than the supply. This is particularly the case in the better grades of iron, and No. 1 foundry is extremely scarce. Of course that state has been general for some time, but despite all efforts to increase the tonnage the shortage continues and consumers keep crying out for larger deliveries. With the steel-makers so busy the consumption of hematite iron is heavy. Export is small. Prices are very firm, and with costs continuing in an upward direction a further rise in pig-iron seems more than probable in the near future.

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THE 6-HOURS' DAY IN GERMANY.—The German Minister of Economy, Herr Robert Schmidt, has published a statement concerning the unions' demand for the 6-hours' day, in which he emphasises the disastrous consequences which would follow such a step. The German industries already suffer keenly from shortage of coal, and many thousands of workmen are idle on this account. Some of the most important German industries, such as the paper, glass, porcelain and nitrogen industries, have lately only received 10 per cent. of their requirements of coal. If the miners carry their demand for a 6-hours' shift, it will simply mean that thousands of German workmen will be deprived of their means of subsistence. Notwithstanding this serious state of affairs the miners seem determined to insist on their demands, but they will endeavour to carry their point without resorting to a strike.

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SHIPBUILDING IN BRAZIL.—The launching in December last of the ss. Itaquatia, from the shipbuilding yard of the Companhia Nacional de Navegaçeo Costeira, is an event of considerable interest, in that this vessel is the first steel ship of any considerable size so far built in Brazil. The Itaquatia is a twin-screw steamer with an overall length of 300 ft., a breadth of 43 ft., and a depth of 18 ft. 9 in., and its deadweight capacity is over 4,000 tons. The Costeira shipyard, in which the vessel was constructed, is situated on the Ilha do Vianna, Rio de Janeiro, and hitherto has been engaged mainly in repair work. Arrangements have, however, been completed between the Costeira Company and Messrs. John I. Thornycroft and Co., Limited, and the works have now been placed under the management of the latter firm, who have sent out a general manager, shipyard and engineering managers, and a number of draughtsmen and skilled workmen from their Woolston works. Considerable developments and improvements have been made during the war, and, since the establishment will now work in close touch with the Thornycroft organisation in this country, there is little doubt that the progressive policy already inaugurated will be maintained. The works, which are completely self-contained, include building berth 400 ft. in length, a dry dock of the same length excavated from the solid rock, and well-equipped machine shops, foundries and smithies, in which the engines for the Itaquatia were built. The work now in hand includes another vessel identical with the Itaquatia, three steam tugs, a number of lighters, and a variety of repair work for which the works are well adapted. About 1,500 men, mostly Brasilians, are now employed in the works, and accommodation for the men and staff is provided on the Island which is an ideal arrangement.

## NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, February 14, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion: "The Difficulties and Dangers of Mine-Rescue Work on the Western Front; and Mining Operations Carried Out by Men Wearing Rescue-Apparatus," by Lieutenant-Colonel D. Dale Logan [Trans. Inst. M.E., vol. lvii, page 197, and vol. lviii, page 149]; "Accidents Due to Structural Defects of Apparatus or Injury to Apparatus; and the Future of the Proto Apparatus," by Lieutenant-Colonel D. Dale Logan [Trans. Inst. M.E., vol. lvii, page 223, and vol. lviii, page 149]; "Sinking a shaft by the François Cementation Process at the Brymbo Steel Company's H lditch Ironstone Mine, Chesterton, Staffordshire," by Messrs. A. Hassam and T. T. Mawson [Trans. Inst. M.E., vol. lviii, page 16]; "Notes of an Explosion of Coal-Dust at Pennant Hill Colliery, near Dudley, Worcestershire," by Mr. J. R. Felton [Trans. Inst. M.E., vol. lviii, page 111]. A new oil safety lamp will be exhibited, described and demonstrated by Messrs. Patterson and Co.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, February 14, the sixth lecture of session 1919-20 will be given in the Assembly Room of the Cycling Club, by Mr. H. L. Reason, of the British Foundrymen's Association, Birmingham. Subject: "Copper Alloys, Brasses, Bronzes, and Anti-friction Metals." Chair to be taken at 6.30 p.m. by Mr. W. H. Poole.

THE SURVEYORS' INSTITUTION.—Monday, February 16, when a paper will be read, entitled "Survey on the Western Front," by Captain William H. Tapp, M.C., Fellow. The chair will be taken at 8 p.m.

THE ROYAL SOCIETY OF ARTS.—Monday, February 16, at 8 p.m.: Cantor Lecture, "Recent Researches in the Cellulose Industry," by Mr. Charles Frederick Cross, B.Sc., F.R.S., F.C.S. (Lecture I.) Wednesday, February 18, at 4.30 p.m.: Ordinary Meeting, "English Canals and Inland Waterways," by Mr. Sidney Preston, M.Inst.C.E., C.I.E., Vice-Chairman of the Canal Control Committee (Board of Trade). Mr. Arthur Neville Chamberlain, M.P., will preside.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Tuesday, February 17, at 7.30 p.m., Art Building, Liverpool University, Mr. S. Clowes, Wh.Ex., on "Elementary Calculus," being the seventh lecture of the series. Wednesday, February 18, at 7.30 p.m., Engineering Lecture Theatre, Liverpool University, Mr. J. Claughton, on "Reinforced Concrete Beams." Thursday, February 19, at 8 p.m., Milton Hall, Manchester, paper on "Commutators as Structures," by Mr. R. J. Roberts, A.M.I.M.E., to be read by a local member. Friday, February 20, at 8 p.m., Y.M.C.A., Bothwell-street, Glasgow, Mr. J. C. Wylie, on "Cylindrical Rollers"; and at 7.30 p.m., Technical School, Barrow-in-Furness, Mr. T. C. Dickie, on "Items of Interest Concerning Furness District"; and at 7.30 p.m., Applied Science Department, Sheffield University, Messrs. P. A. Arbenz and H. W. Mellor, on "Design of a 40-Ton Titan Crane," being an official Association Lecture.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, February 17, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi. The following paper will be read: "Recent Patents on Mixed Fuels," by Dr. W. R. Ormandy, D.Sc., F.C.S. The chair will be taken by the president, Sir Frederick W. Black, K.C.B.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—Tuesday, February 17, at 7.30 p.m., at the Assembly Rooms, Royal Victoria Hotel, Sheffield, a lecture will be delivered on "Steel-Making in India," by Dr. A. McWilliam.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 18, at 8 p.m., Meeting of the Session will be held at the Royal Institution, Colquitt-street, Liverpool, when a paper will be read by Mr. E. A. Atkins, A.M.I.Mech.E., entitled "Steel Wire and Wiredrawing."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, February 18, at 6 p.m., Wireless Sectional Meeting at the Institution of Civil Engineers, Great George-street, Westminster. "Wireless Telephony on Aeroplanes," by Major C. E. Prince.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, February 18, at 3 p.m., in the Mappin Hall, Applied Science Department, The University, St. George's-square, Sheffield. The following papers will be read: (i) "The Preservation of Glass Furnace Refractories by Water Cooling," by Mr. E. B. Christmas, A.M.I.Mech.E. The paper will be illustrated by lantern slides. (ii) "A New Glass Furnace," by Mr. M. B. Travers, D.Sc., F.R.S. Exhibition of a Kinematograph Film showing "The O'Neill Bottle Machine in Operation," by Messrs. Ingersoll-Rand Company, 165, Queen Victoria-street, London, E.C. 4.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 18, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read: (1) "The Status of a Meteorological Office and its Relation to the State and to the Public," by Captain C. J. P. Cave, F.R.Met.Soc.; (2) "Atmospheric and Terrestrial Radiation," by Mr. W. H. Dines, F.R.S., F.R.Met.Soc.; (3) "Internal Friction in the Atmosphere, by Mr. D. Brunt, M.A., B.Sc., F.R.Met.Soc.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, February 19, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London. The following paper will be submitted for discussion: "The Use of Haloid Cyanides for the Purpose of Gold Extraction," by Mr. T. B. Stevens, Member, and Mr. C. E. Blackett, Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 20, at 6 p.m., Annual General Meeting at the Institution, Storey's Gate, St. James's Park, S.W., the Annual Report of the Council will be presented; alterations of, and additions to, by-laws; resumed discussion on "Recent Advances in Utilisation of Water-Power," by Mr. Eric M. Bergstrom, of London, Associate Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 20, at 9 p.m., a discourse will be delivered by Mr. Edward J. Russell, O.B.E., D.Sc., F.R.S. The subject is "British Crop Production." Afternoon Lectures, at 3 p.m.: Tuesday, February 17, Professor Ernest Wilson, M.Inst.C.E., M.I.E.E., on "Magnetic Susceptibility" (Lecture I); Thursday, February 19, Mr. Arthur H. Smith, M.A., F.S.A., on "Illustrations of Ancient Greek and Roman Life in the British Museum" (Lecture I); Saturday, February 21, Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., M.R.I., on "Positive Rays" (Lecture I).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 20, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., "Obscure Points in the Theory of the Internal-Combustion Engine," by Professor F. W. Burstall, M.Sc., M.A., Hon. Member.

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GERMAN MOTOR-CAR CONTRACTS.—The fact that the German motor-car industry as a whole, and with it other industrial undertakings, have seen fit to cancel all agreements entered upon prior to or during the revolution, has been somewhat severely criticised in various quarters, and the Union of German Motor-Car Manufacturers has now issued a communication of an explanatory nature. It is argued in this statement, that the line of action adopted was most reluctantly undertaken to avoid losses and in the interest of the workmen, and that it was the workmen themselves who unanimously arrived at this decision, in their own vital interest. There is no question of any pressure having been brought to bear upon the workmen's committees. Reference is also made to some legal decisions which favour the view that the manufacturers cannot be held to deliver on the original terms on account of the altered conditions of labour and wages, and, more especially, of the present position of the mark. The Upper Court of Stuttgart has even pronounced in favour of cancelling contracts made as late as the middle of 1919. Reference is made to the cancelling in the summer of 1919 of all the contracts of fixed prices of the Shipbuilding Steel Bureau. In future motor cars can only be sold subject to the so-called Hausse clause, that is on a sliding scale of prices. The motor-car manufacturers, in view of their own vital interests, greatly regret the necessity for automatically raising the prices for motor cars, as this puts considerable difficulties in the way of selling. According to the statement issued the industry wants a just distribution of the increased cost arising out of the altered conditions and has no intention of acting in a dictatorial manner. It will always endeavour to complete contracts in a fair manner wherever this is possible, but unfortunately there are financial limits in this connection. The statement has not met with a very encouraging reception, and some scepticism is expressed as to the decision of the workmen, but it is generally admitted, that at the present time it is impossible for employers to bring any pressure to bear on their men.

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TEMPERATURE COEFFICIENTS OF PERMANENT MAGNETS.—The magnetic moment of a permanent magnet changes when the temperature changes, and the reversible change of the moment, expressed in per cent. per degree Centigrade, is known as the temperature coefficient. When we magnetise a bar, and observe the deflections of a magnetometer which it produces at ordinary temperature and at 100 deg. C., we notice that the latter deflection is smaller, and that hence the permanent magnetism has been diminished by heating. But part of this diminution disappears again as the hot magnet cools; the change is therefore partly reversible, and the irreversible portion becomes smaller and smaller as we repeat the heating and cooling, so that finally the cooling magnet reattains almost its full magnetic moment. This is the basis of the ageing process of Strouhal and Barus. As regards the material the temperature coefficient of a pure carbon steel decreases as the percentage of combined carbon increases, and by quenching a 1·4 per cent. carbon steel at 1,100 deg. C. E. Gumlich obtained, at the Reichsanstalt, permanent magnets practically devoid of a temperature coefficient. How the modern alloy steels behave in this respect is not yet settled. Apart from its theoretical interest the problem is technically important, as, for instance, for the magnets of electricity meters. The question of the shape of the magnets to which Canceni (1887) and later Ashworth drew attention, also enters into this question, and this part has recently been investigated by Gumlich (*Annalen der Physik*, September 4, 1919, pages 663 to 688), so far as war conditions permitted of exact magnetic research. The method used was that of Gauss. The alloy steel contained 0·72 per cent. of carbon and 3·26 per cent. of chromium, and was heated up to 100 deg. C. in an oil bath; it was tested in bars, in complete rings, and in rings and horseshoes of different pole gaps. It appeared that the smaller the gap, the smaller also the temperature coefficient; on the other hand the coefficient increased when the dimension-ratio (length to width) decreased. It had been suggested that the actual pole distance diminished as the magnet became warm; but this was not confirmed.

# ELECTRIC DRIVE FOR ROLLING MILL FOR LEAD SHEETS.

CONSTRUCTED BY METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, TRAFFORD PARK, MANCHESTER.

(*For Description, see Page* 215.)

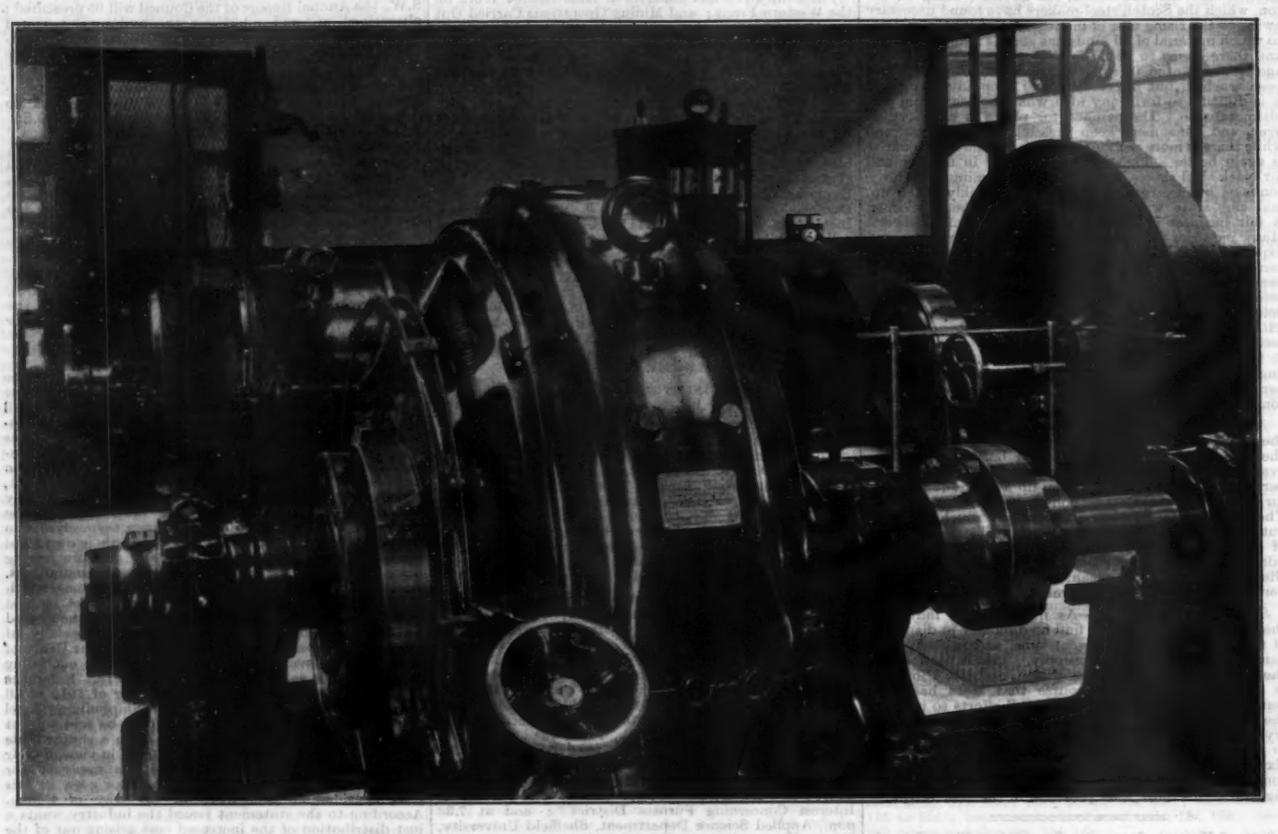


Fig. 3. 90-Horse-Power Reversing Rolling Mill Motor.

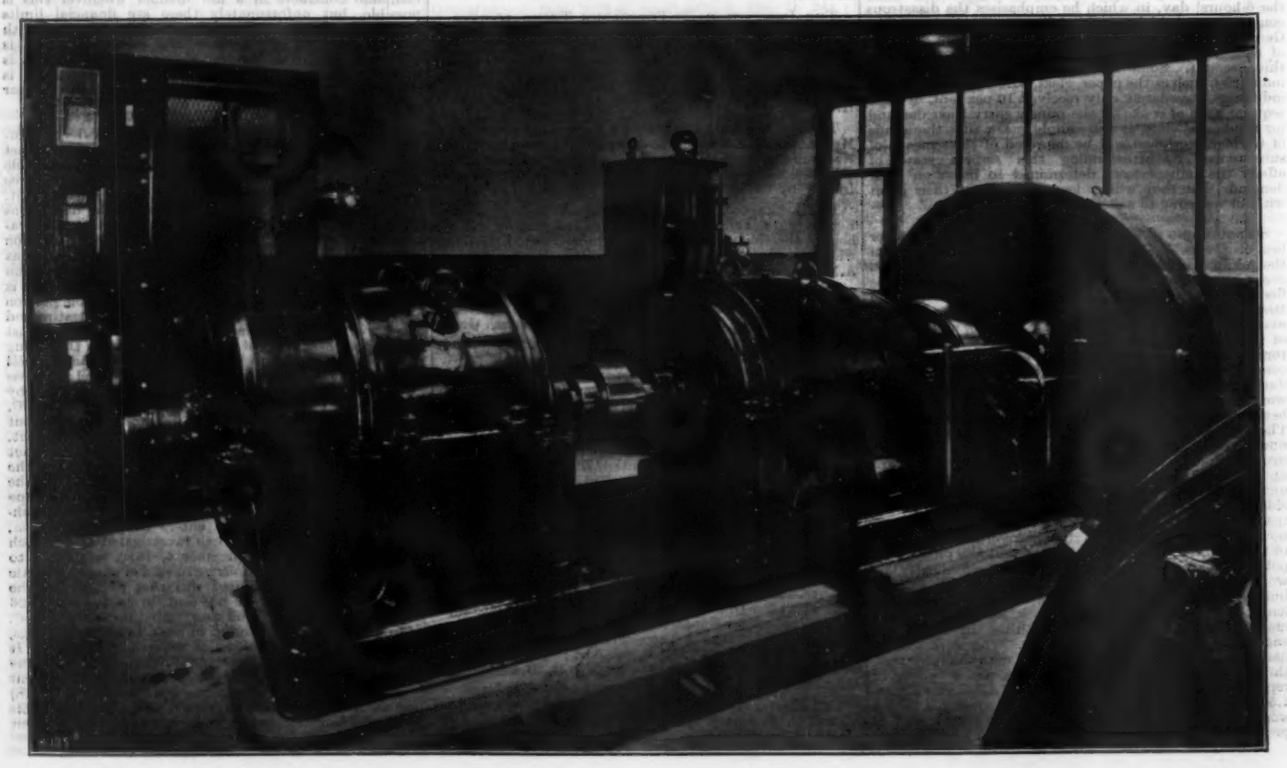


Fig. 4. 75-Kw. Motor Generator Set.

# TRANSMISSION GEAR AND FRONT AXLE FOR THE ANGUS-SANDERSON MOTOR CAR.

CONSTRUCTED BY MESSRS. E. G. WRIGLEY AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

(For Description, see Page 210.)

Fig.1.

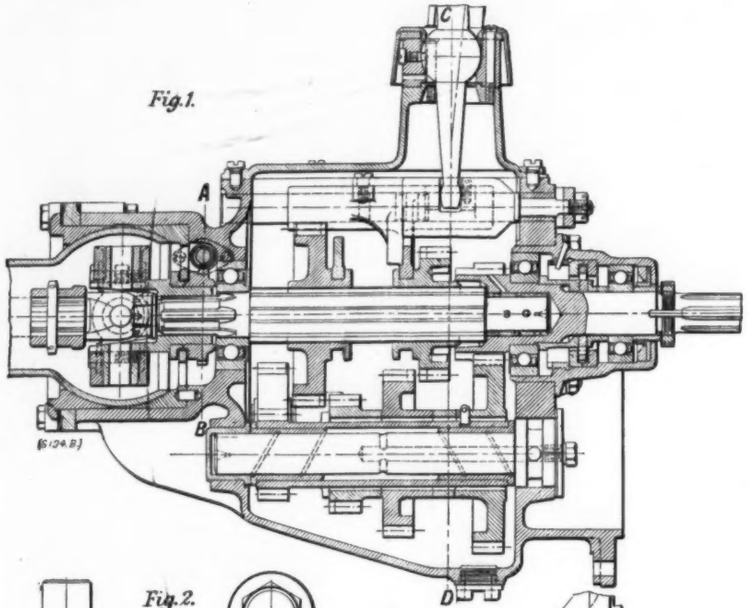
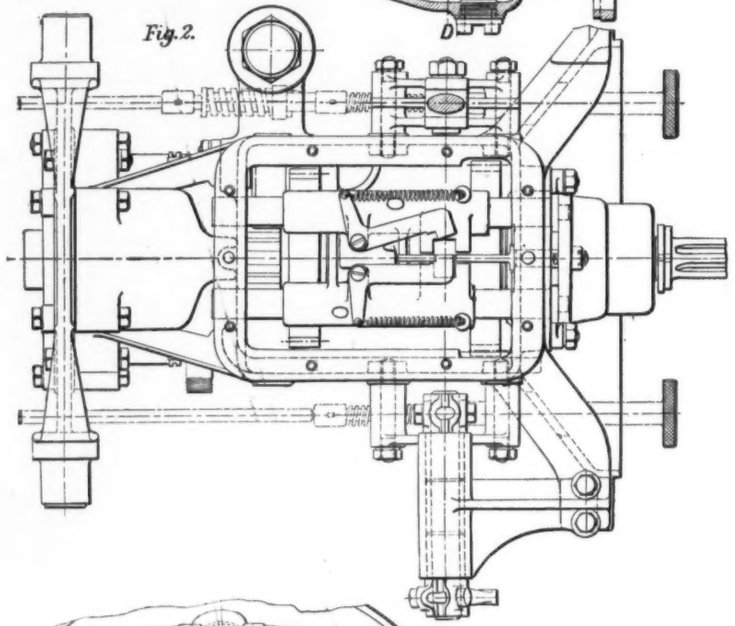



Fig.2.



SIDE VIEW SHOWING BRAKE LEVER.

Fig.3.

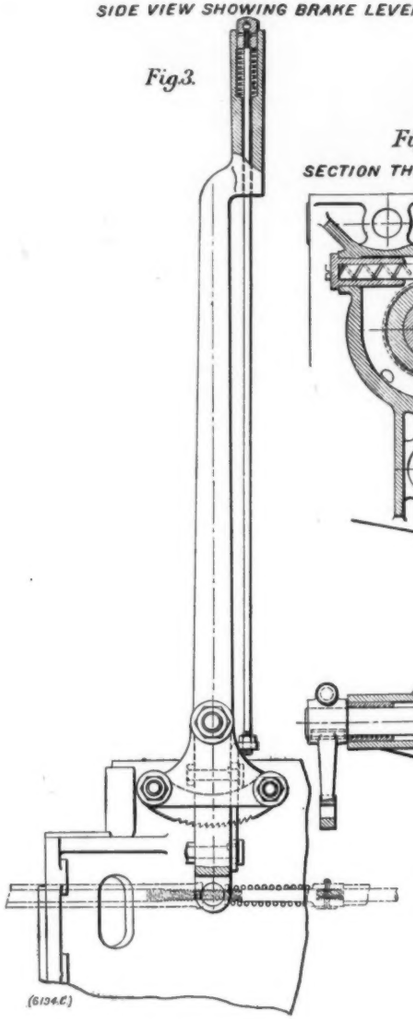



Fig.5.

SECTION THROUGH A.B.



PART SECTION THROUGH C.D.

Fig.4.

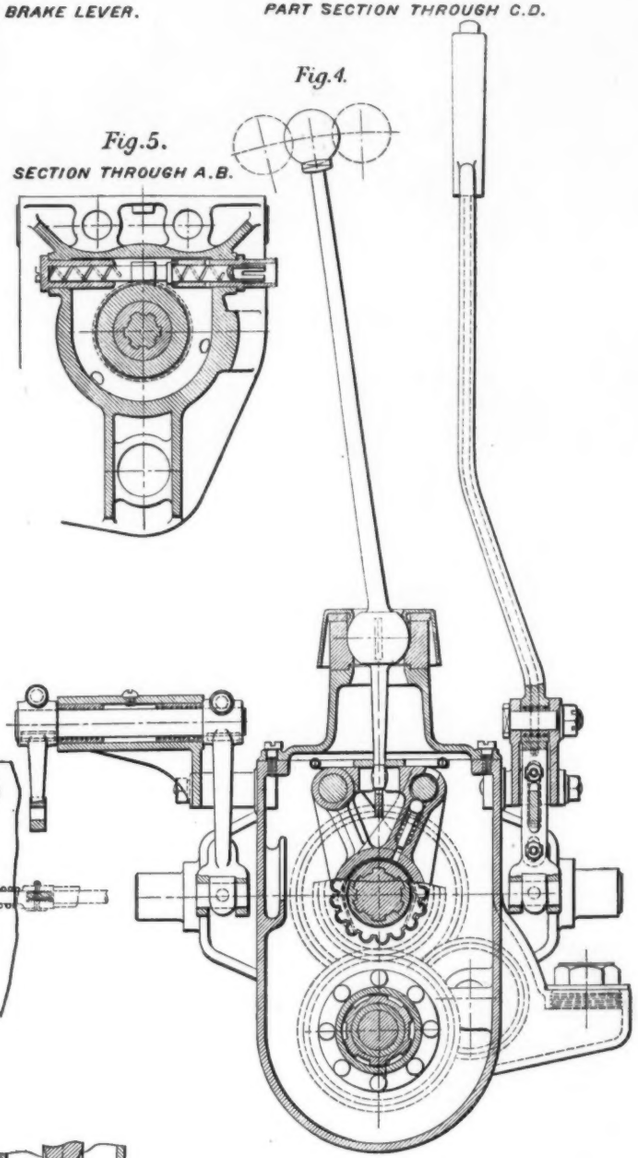
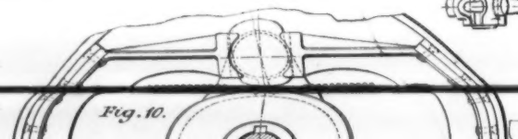


Fig.10.



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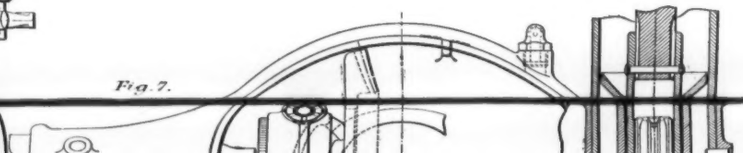

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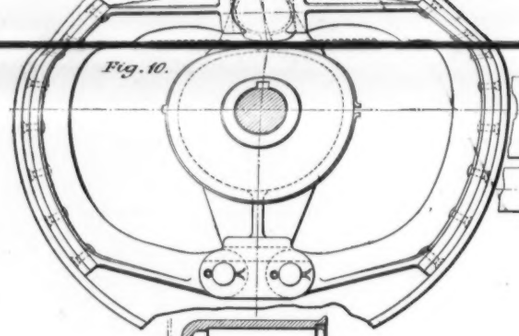

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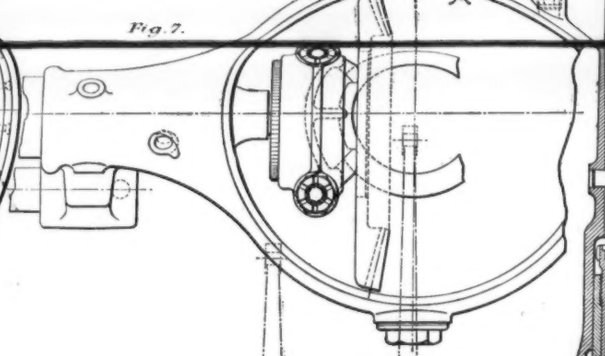

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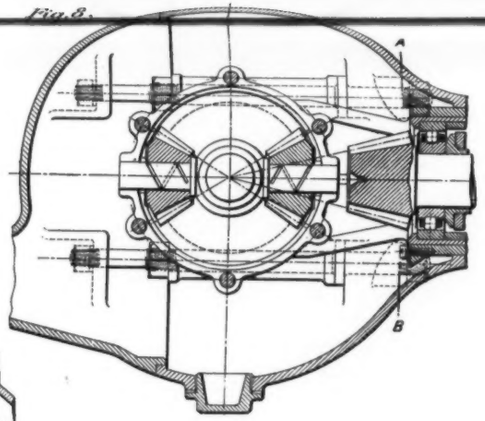


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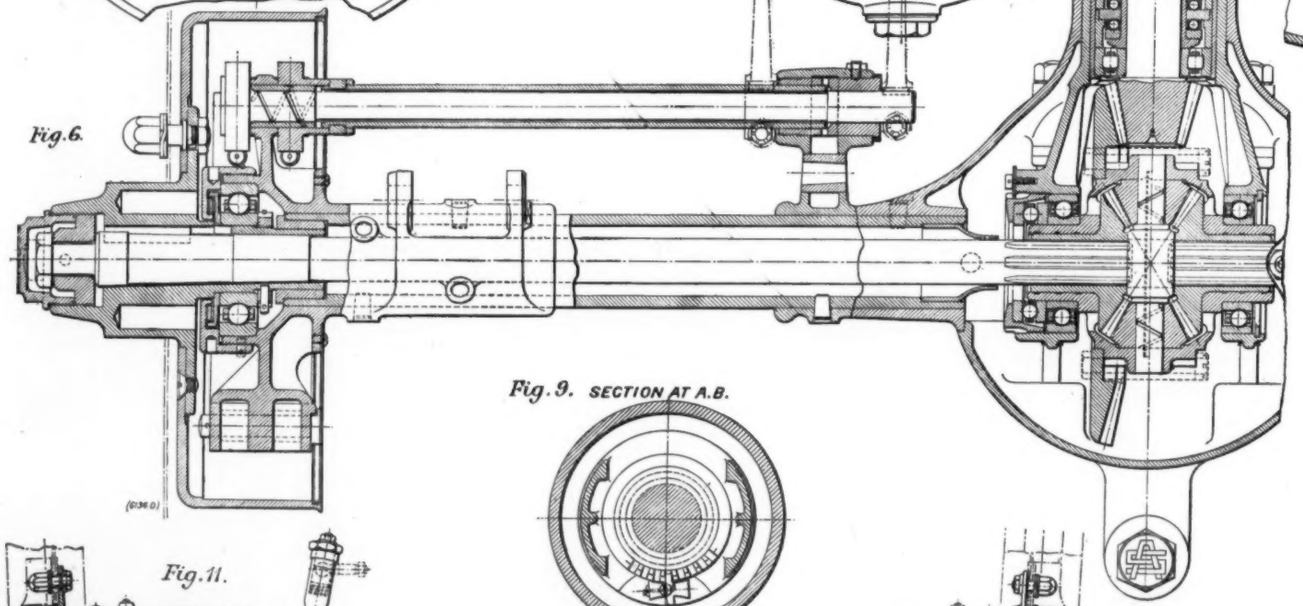

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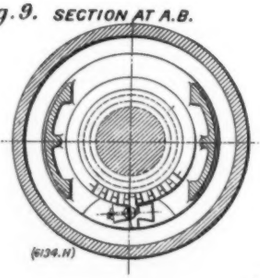

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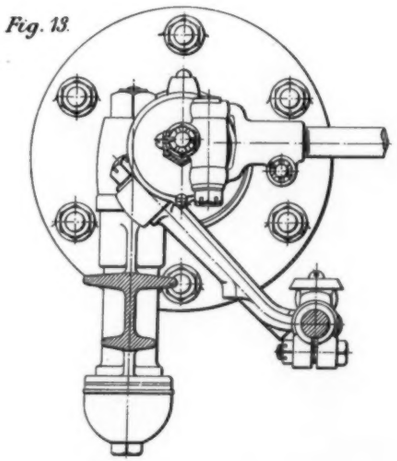

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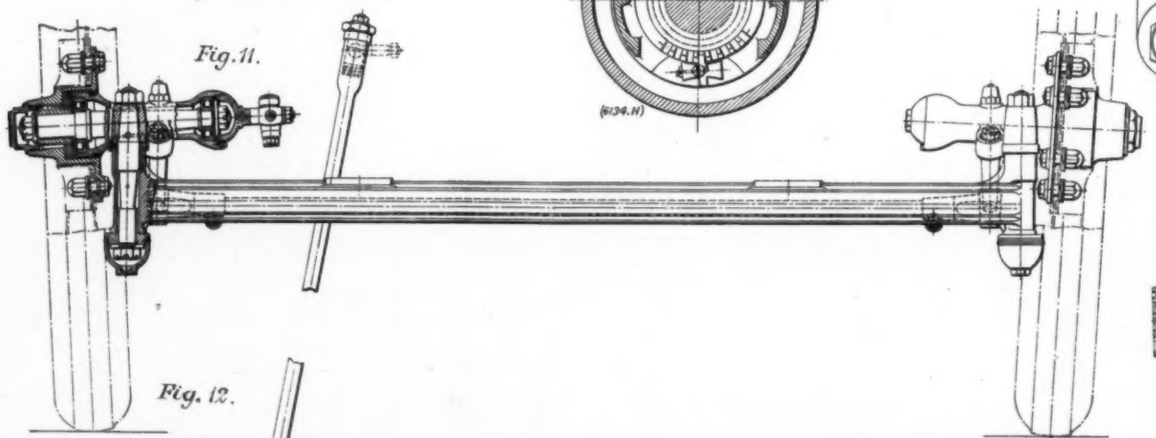
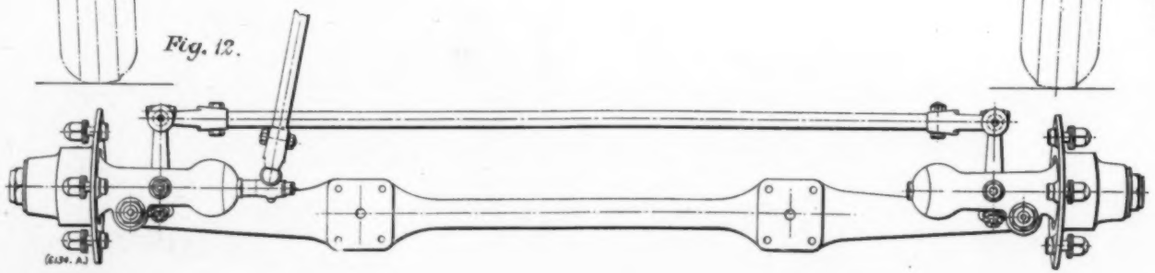


Fig. 12.



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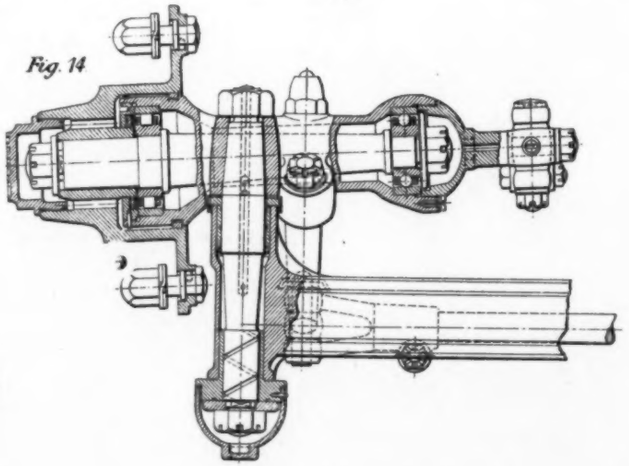

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## SUBSCRIPTIONS, HOME AND FOREIGN.

### REVISED RATES.

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| | |
|---|---|
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| For Canada— | |
| Thin paper copies | £2 16 6 |
| Thick " " | £3 3 0 |
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**We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.**

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON,

TELEPHONE NUMBERS—8605 and 8606 GERRARD.


## CONTENTS.


| | PAGE |
|---|---|
| The Vibration of Spars in Aircraft (*Illus.*) | 201 |
| The Gyrostatic Compass (*Illus.*) | 202 |
| Literature | 206 |
| Books Received | 207 |
| Three-Cylinder 0-8-0 Type Superheater Locomotive; North-Eastern Railway (*Illus.*) | 208 |
| Transmission and Control Gear for Angus-Sanderson Motor Car (*Illus.*) | 210 |
| The Air Cooling of Petrol Engines | 211 |
| The German Electrical Industry | 214 |
| Locomotive used as a Shell Press (*Illus.*) | 214 |
| Electric Drive for Rolling Mill for Lead Sheets (*Illus.*) | 215 |
| Properties of Glue | 216 |
| Notes from South Yorkshire | 216 |
| Notes from Cleveland and the Northern Counties | 216 |
| Notes from the North | 217 |
| Notices of Meetings | 217 |
| The Remuneration of Labour and Increased Production | 219 |
| Losses at Oil Wells | 220 |
| The Trade and Industries of India | 221 |
| The Service of a Technical Society | 222 |
| Notes | 223 |
| Notes on New Books | 224 |
| Water-Cooled Turbo-Alternators | 225 |
| Fluid Motion and Viscosity | 225 |
| Industrial Notes | 226 |
| Recent Advances in Utilisation of Water Power (*Illus.*) | 227 |


*With a Two-Page Plate of the* TRANSMISSION GEAR AND FRONT AXLE FOR THE ANGUS-SANDERSON MOTOR CAR.

## NOTICE.

**Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase dates from and includes the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.**

### NOTICE TO NON-SUBSCRIBERS.

**In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.**

### NOTICES OF MEETINGS.

**Notices of Meetings to take place during the present and next week will be found on page 217.**


# ENGINEERING.

*FRIDAY, FEBRUARY* 13, 1920.


## THE REMUNERATION OF LABOUR AND INCREASED PRODUCTION.

It will not be disputed that success in most matters only follows hard effort, and, in the great majority of cases sterling work meets with its just reward. There are, of course, exceptions. It can further be truly stated that the average man rather "works to live" than "lives to work," and that the great majority are more or less content to do that minimum which supplies the necessities and gives a sufficiency of the commodities of life. The relatively small fraction which form the exception to this general rule will, according to the natural consequences, almost inevitably rise to positions of trust and responsibility in their spheres of action. In attacking all problems it is necessary to attempt to find a solution which will apply to the majority and which accepts the facts as known. How, then, can incentive be given, to the end of raising the status from one of comparative lethargy to one of energy and willingness to achieve the best results? In our workshops many factors have an undoubted influence; management, organisation, equipment, working conditions and systems of remuneration all play their part, and each is strongly linked up with the others. These are not necessarily stated in their order of importance. Primarily it is with the last-mentioned, *i.e.*, systems of remuneration, that we are for the present concerned in view of negotiations between employers and workers in the engineering trades and of the impending ballot of the latter.

The standard method of remuneration in the engineering and allied industries at the present time is the hourly wage or time-rate system, where long service and exceptional ability are rewarded by an addition to the time rate, and, further, where certain increases are given in exceptional circumstances. Apart from this differentiation all workers at the same trade are paid the same hourly rate. This method of payment has, of course, much to commend it. Its merits may be chiefly negative in character. It avoids all the pitfalls inseparable from the introduction of any system of payment by results. It will not prevent a first-class tradesman from continuing to give of his best. No objections on the part of the workers will be raised to this system of remuneration which is generally most favourably regarded by them. On the other hand, it is felt that as time advances time-work is less able to meet the demands of the present. Workers clamour for an increased share in the profits of industry, the world shortage of raw materials and engineering products must be made up, and our own economic and financial position demand the maximum production. The only formula at present available for application which will square these two factors is a system of remuneration according to results giving an incentive to higher effort.

There may be said to be four main systems: Profit-sharing, collective contract, individual piecework, and the bonus systems. All payments by results are, of course, profit-sharing to the extent that the less the time occupied to do a given piece of work the greater the hourly earnings, which extra or bonus payment may be said to be in lieu of direct participation in the profits. To extend profit-sharing further than this does not seem altogether logical. Why should the profits be shared with those who incur no direct loss in times when no profits are earned? The right to participate in profits incurs the responsibility for actual loss, and the fact remains that our engineering industries prior to the war made on the average very small profits.

The collective contract system has made considerable headway during the war, and is particularly applicable to repetition work such as shell work and munitions work of a similar nature. This arrangement has the disadvantage of only giving slight encouragement to individual effort, and entails considerable responsibilities upon those whose duty it is to fix up the contract price when a new type of product is to be undertaken. It has the advantage, however, of bringing under a bonus scheme classes of workers required in every shop who cannot readily be put upon an individual system.

As conferring, however, the greatest benefits the individual systems are greatly to be preferred, and the differences between the individual piecework and the individual bonus systems are relatively slight. By an individual system is meant such a system that each worker, so far as possible, is given a price or a time for each piece of work carried out. In cases where two or three men work together, such as when facing-up the same surface, or in boiler-making work, for instance when building the same uptake, collective piecework or collective bonus is, of course, worked, each man booking his time to the job; and all sharing the same percentage of bonus. In piecework the job is assessed in terms of money, and in the bonus system in terms of hours. The two bonus systems most commonly worked are the "Halsey" and the "Rowan." With the former the man is credited generally with half the time saved, and in the case of the latter the percentage which the time saved bears to the basis time is added to his time rate. When dealing with these systems it is frequently the custom to show elaborate curves and tables indicating the differences. With such methods of explanation the possibility of equally correct actual times being assessed for the jobs in view, is assumed. This is far from being a practical possibility. Not only is there a difference in the capability of the workers, but circumstances in every shop are constantly changing. If absolute accuracy were possible and the variation between individual workers were slight, little exception could be taken to the piecework system, excepting its tendency to foster thought in terms of money rather than terms of time taken, which must, after all, be the original basis for all systems.

The difference in the amount of extra remuneration given to the worker does not so much depend on the details of the system as on the accuracy of the original estimate, and the manner in which the system is administered. A job can be taken out for time and a quarter as readily on piecework as on either of the bonus systems, and if the estimate is accurate, then it is exactly a measure of what will be earned, apart, of course, from variations in capacity of the various workers. Unless standard methods are in operation the difference in time required by one, as compared with another, will be found to be greater than would be supposed. The rate-setting must be most accurate with piecework. Slightly greater latitude is possible with the Halsey system, and whatever mistakes, by way of an excessive estimate, are made with the Rowan system, more than double time cannot be earned, so that for varied work of a general nature the Halsey system is probably the most satisfactory. An objection raised to the Rowan system is that more than double time cannot be earned, thus stifling initiative, and the worker settles down and is content to make time and a fixed percentage—often time and a half. What is of much greater importance with these individual systems than the actual details of the system itself, is the method in which it is operated. Those who have had experience of this subject will appreciate the difficulties which can be met with and the objections

which will be raised. First, the workers desire a guarantee, which will be referred to later.

Generally the workers do not favour the competitive spirit that is undoubtedly fostered by the individual system. The aim of many is undoubtedly towards the Utopian ideal of eliminating the doctrine of the survival of the fittest. In our management of social affairs at the present time we have travelled a considerable distance in this direction by shouldering upon the most efficient members of society many of the burdens of the less productive. This aspect of the question is rather broader than can readily be dealt with in this article. Certain it is that there must be a general willingness to work without which competition will be found to become too severe, and considerable unemployment will set in and cause the whole standard of living to be reduced. Until such time as international competition can be regulated, if ever, the law of the survival of the fittest is bound to operate, and no artificial levelling-up can do other than minimise slightly its worst effects. To put the matter bluntly, when, due to keen-cut competition and failure to obtain work, an industry, or branch of industry, becomes slack, workers must be paid off, and those who are paid off, whether payment by results operates or not, will be those whose capacity for work is least. These, then, are briefly the objections which must be met.

The one method which must not be adopted in fixing piecework prices or bonus times is to glance at the job and to guess at the time which it should take to accomplish. Good shop practice cannot be built up on such a foundation. The job should be split up into its component parts. To take an example:—

1. Altering or setting-up the machine, collecting tools, applying jigs, &c.

2. Actual cutting or working time based on the capacity of the machine and the degree of finish and accuracy required. This fraction of the total should be further split up as may be found desirable, according to the type of work, and suitability for other classes of work.

3. Removing the job from the machine, testing, &c.

The sum of the times allotted to each of these items gives the actual minimum time. This time then represents that in which the job would be done assuming it to be a repetition job, to which must be added the percentage according to the details of the system which is being worked. Fifty per cent. time added with the Halsey system gives a man doing the job in minimum actual time, time and a quarter; similarly with the Rowan system.

In the case of piecework this actual time must be translated into money according to the hourly time rate or rates of the man or men employed on the work, and according as to whether the man is being taken out for time and a quarter, or whatever percentage operates in the shop. If, however, only one off is to be done, then it is only reasonable to assume that in the majority of cases it will be impossible for the worker to get into his stride in such a short time, and extra allowance can be given for one off. In shops where one or two off is the general rule, then the actual minimum time is assessed somewhat more generously than has been indicated, or alternatively, allowance by way of time and money is made on the job to enable the worker to study the best method to employ, &c. Furthermore, it is quite possible that the operation may be held up through no fault of the operator, such as, for instance, a breakdown in the tools, the overhead crane for shifting the job on the machine not being available, or having broken down, extra hard material being encountered, the job being held up on the machine for extra inspection, &c. These being no fault whatsoever of the worker, must all be allowed for as extras. It will be seen, therefore, in dealing with a large shop engaged on a variety of work, that the labour imposed by working an individual payment by results system, is considerable. All the factors enumerated have to be considered for each individual job.

With records carefully kept and a steady run of work, data will rapidly accumulate to enable times to be given without going through this process of calculation for each job, but only with such a process at the commencement can a system be built up which will prove increasingly satisfactory. What, then, are the pitfalls to such a method of working? In the inaugural period the amount of discussion and argument which will take place between the men and those responsible for fixing the rates as to the times to be allowed for the various elements of any piece of work, is considerable, but this decreases when confidence in the rate-fixer is gained. It must be strongly urged that:—

1. No system of payment by results should be introduced into a shop until it is assured that a steady run of work is available. It has frequently happened that payment by results has been introduced, the work has been speeded up, and the supply of new work has not been available, with the result that men have been paid off. Such instances, when they occur, give rise to the fallacious belief—not infrequently held—that increased production means less employment. Increased production can only mean increased prosperity, and increased prosperity means steadier employment for greater numbers. On the other hand, those who are paid off cannot be expected to take a long view, and an unemployed man will find little comfort in the reflection that those still at work are earning relatively high wages under a system of payment by results.

2. Time work and payment by results should not be worked intermittently. As many men as possible should be simultaneously put on payment by results, and arrangements made to keep them continuously on this system. The disadvantages and bad practices which can and will arise with intermittent working are well known, and do not require explanation.

3. Before introducing a system of payment by results it will be well to ensure that the methods in vogue in the shop are the best possible with the plant available, otherwise the introduction of the bonus system will bring improved methods in its train and difficulties may be experienced as a result of these improved methods, if their initiation is left to the workers.

A system operated on the lines as laid down will have the substantial advantage of bringing to light many factors which otherwise would remain obscure. Shortage of work for any department will more readily be apparent, since men earning bonus will frequently not be content to go back on to the plain time rate, without protest. Extra allowances of money or time which have to be given to cover deficiencies in plant, breakdowns or faulty organisation, are duly recorded, and can regularly be totalled, making a good case often for new plant or new methods which might not otherwise have suggested themselves. These are only stated in passing as some of the subsidiary advantages.

We may now turn to another aspect of the question which cannot be neglected, that is, who is to fix the prices or the bonus times? Sometimes this is left to the foreman in charge of the shop, and sometimes it is preferred to have a separate rate-fixing department, and the requisite staff. The system which has been laid down is not capable of being worked by the foreman of the department, whose duties are often already too multifarious to warrant the imposition of this further task. The advantages of a separate department in co-ordinating the methods of rate-fixing and the basis times and prices in various shops will at once be appreciated. The subject is one still requiring keen application, since there are very few members of our staffs to-day who have become accustomed to subdivide jobs into their elements and to assess the correct time for the carrying out of these elements of work. Whilst it is recommended that the duties of rate-fixing should be separated from those of foremanship, it is certain that payment by results cannot be successful in any shop without the hearty co-operation of the foreman.

It is to be urged upon all those who are responsible for output in a shop (and that, of course, is one of the principal duties of the foreman) to study this subject, since its bearing on the question of output is direct and considerable. The ability should be required of being able to split up jobs into their component parts, and to assess a time value to these components, with a view to assisting in the most difficult task of setting fair and just times and prices, especially for new types of work.

## LOSSES AT OIL WELLS.

The conservation of natural resources formed the theme of many a dissertation long before the war came to impress upon us the need of making the least go as far as possible in a manner never experienced before. In these days of difficulty regarding coal, it is deplorable to think of the millions of cubic feet of good natural gas which for one reason or another have been allowed to escape utilisation and become irretrievably lost. If they could only have been saved and taken to a market how useful they would have been! The loss of gas at oil wells has been astonishingly large. Steps have often only been taken to utilise the supply when it has already begun to fall off. From one bore alone 40,000,000 cub. ft. per diem escaped for a considerable time. This almost criminal neglect has been attributable to the fact that there was often no immediate market for the gas, while oil was in great demand; the former therefore was sacrificed for the latter. The terms of the drilling contracts often tend to a waste of gas, as steps taken to conserve it would delay striking oil.

There is not to-day the same excuse for this waste as there was in the earlier pioneer days. Apart from power production at the site, or its transport to a town market, there are other uses to which such gas can be put if salved. For some time now gasoline has been produced from it by a process of compression, frequently a very good yield being obtained, and leaving only a comparatively poor, dry residual gas. This, if no particular use offers, must be discarded, but there will be the satisfaction that it has been robbed of its valuable constituents. The extent to which the recovery process is now adopted may be gauged by the fact that since 1910, when the process passed beyond the experimental stage, it has steadily increased till in 1917 it was in use at 886 plants, producing 218,000,000 gallons in the year. Pressures in bores vary from anything up to 500 lb. and 800 lb. per square inch. Escaping from a well at anything like high pressure gas carries off by volatilisation a very large amount of the lighter fractions of the oil. If the discharge is turbulent or in the form of spray, a lot of the rather heavier fractions are also evaporated. This loss is set as high as 25 per cent. with a "wild" well, and even 10 per cent. with a well under control and flowing into an open sump. The light fractions are easily lost. If conserved, there is an enormous market for them. The oil remaining is heavier than it would otherwise be, and having already lost a good part of these lighter constituents, does not give a very large yield of gasoline under distillation.

The terms of contract, under which oil is bought from the wells, differ. In some the selling price is dependent upon the specific gravity which is taken as an indication of the gasoline content. Others ignore this point. In the former case it is to the producer's interest to do all he can to retain the lighter fractions in the oil. In the latter it pays the operator to increase if possible the gasoline content of his gas, and then to recover the gasoline from it. In both cases it pays to control the gas and oil discharge in order to regulate as far as possible this point alone. The reckless operation of wells has been the ruin of many of them. Wells giving a lot of gas mean violent movements of the sand beds. These may result in a well of good promise falling off after a very short time—to say nothing of such points as risk of fire, and the trouble from emulsification of the water and oil, and so on.

All these are arguments in favour of effective control of the gas at the wells by means of suitable traps, from which the gas can subsequently be drawn and handled as desired. A number of these appliances are described in a Bulletin (No. 209) recently issued by the Department of the Interior, Bureau of Mines, Washington, U.S.A. The character of the flow of wells varies to a very great extent, and a number of different methods of control have therefore to be adopted. Some flow under a small pressure and others under high pressures. Some are pumped and some flow intermittently, emitting

great quantities of gas between the "heads." The use to be made of the gas and oil partly decides the method to be adopted, and traps to suit high or low pressures, or to work with a vacuum, are, practically speaking, operated to regulate the gasoline content of the issuing gas.

The effect of a vacuum on the oil from a small well is similar to that of a well at high pressure discharging into the air, viz., to enrich the gas by retaining in it in vapour form many of the lighter fractions of the oil. The vacuum trap therefore gives a high gasoline gas suitable for the compression process of recovering gasoline.

On large wells with a heavy flow under high pressure, the release of pressure at the discharge, of the mixture of gas and oil and sand and water, results in a great deal of volatilisation. If the pressure be partly or wholly retained the gas and oil may be separated out without disturbance or loss. In separation under pressure the lighter fractions remain in liquid form in the oil, and dry gas is the result. If, however, the pressure under which separation is carried out is on the high side, some of the absorbed fractions will become released from the oil on the inevitable subsequent drop of pressure, and will carry away with them other volatilised fractions. This critical pressure has to be determined for each well, as it varies with the quality of the oil.

The essential feature of all traps is a large sealed separator chamber from which the gas is drawn off at the top and the oil from the bottom. The types in use vary in form according to the class of well to be treated. Some, for wells flowing under small pressures, consist of little more than a cistern, standing in which is a length of casing tube open at the bottom end, and closed at the top by a flange. Through this flange pass two small pipes, one terminating just inside the tube and the other passing down some distance further. The well-discharge passes through the latter into the length of casing tube, where the gas and oil separate. The former rises to be drawn off through the second pipe in the flange, while the latter falls and gradually fills the large cistern from which it is drawn away. Such traps are useful only for small pressures amounting to a few inches, and for wells of regular flow, but they can deal with oil carrying a certain amount of sand. The essential feature of the separating chamber to reduce the velocity of the discharge is embodied in it, as is also the necessary seal on the oil discharge end. If the material available makes it preferable, the large tank may be discarded in favour of a longer casing tube, up to even 60 ft., fitted at the base with an elbow leading to an inverted U of smaller pipe about 30 ft. high. The latter provides in this case the required seal. By increasing the height of the U-tube, the pressure for which this trap may be used can be increased over a moderately wide range. It has the advantage of utilising material commonly available on the spot, and can be erected against the derrick, or laid on a slope on the ground. These two traps are both automatic.

Another simple form of trap used on wells discharging about 20,000 barrels and several million cubic feet of gas per day, together with a good deal of sand, consists of a vertical tube up to 12 in. in diameter, extending from the ground to a height of 90 ft., fitted some 40 ft. from the ground level with a tee and branch pipe coupled to the well discharge. At the top of the vertical tube a pipe is fitted with a cock to control the gas discharge; at the bottom a large oil discharge pipe is fitted, also with a control cock. If the velocity of the incoming stream is high the mixture rises in the vertical tube to a height which can be regulated by the two control cocks. This type of trap is difficult to control when the flow is very irregular. It is not automatic, but any pressures up to the strength limit of the material can be dealt with.

On gusher wells in California two types of horizontal tube traps are in use. In one, the trap consists of a separating chamber 180 ft. long and consisting of casing about 15 in. diameter. At intervals of about 4 ft., inverted U's connect this with another horizontal pipe of 5 in. diameter. The combined area of the inverted U's is greater than the opening into the trap through which the well products are admitted, so as to allow the oil to become quiet and the gas to separate out. The gas rises through the inverted U's and collects in the second horizontal pipe, while the oil collecting in the main pipe is run off at the end opposite that at which it enters. A chamber may be inserted near the oil discharge outlet, for the purpose of collecting the sand. These details compose the essential features of a trap known as the Starke trap, and used largely on wells in California under high pressures. It is customary in these cases to keep the full well-pressure on the trap, instead of restricting the pressure at the well head and working the trap under low pressure. In this way emulsification is avoided, and a dry gas fit to be discharged into high-pressure mains for long-distance transmission is secured. This trap is not automatic.

Another Californian trap made of piping, &c., is the Bell trap. This consists of an inclined pipe of about 12½ in. diameter, and 240 ft. long, fitted at the upper end with a reducing nipple and a tee. Passing through the tee and down for about 170 ft. into the 12½-in. pipe, is a 6-in. pipe perforated for some distance at the lower end. At the lower end of the main pipe is a vertical chamber enclosing a float which works a butterfly valve in the discharge connection from the main pipe. Oil and gas enter by the 6-in. pipe, the former collects in the lower portion while the gas rises in the upper portion of the main pipe. The gas is drawn off from the annular space between the 6-in. and the 12½-in. pipes, by the branch of the tee. The float and chamber regulate the opening of the butterfly valve according to the level of the oil in the large sloping pipe. This trap has handled very large discharges, and a considerable amount of sand does not interfere with it as the valve is only a loose fit and never closes completely. It is suitable for any pressure.

There are numerous types of automatic traps mostly designed for comparatively small pressures. These usually comprise a closed cylindrical tank with some form of float-operated valve. In some the valve is internal and in others external. The essential lines of construction are similar, though they differ in innumerable detail. They are not as a rule suitable for dealing with oil containing much sand. An interesting form of trap which is made in modified form to meet the requirements of the three main types of well, is the McLaughlin trap. This consists essentially of a suspended tank, through the bottom of which projects the fixed stem of a mushroom valve. The stem is fixed to the structure of the trap and the tank moves vertically on it, being hung by spring suspension or by lever and counterbalance. The well discharge is led into the tank at the top; the oil and sand fall over baffle plates, to the bottom, and when sufficient have accumulated the strength of the suspension springs, or the effect of the counter-balance, is overcome and the tank falls, opening the mushroom valve in the bottom. With steadily flowing wells the balance can be effected to such a nicety that a continuous discharge issues at this point while the outflowing oil itself acts as a seal and prevents air from mixing with the gas. The presence of a considerable amount of sand does not interfere with the working of this trap. The gas is drawn off through a flexible pipe at the top.

## TRADE AND INDUSTRIES OF INDIA.

INFORMATION concerning the trade of India in all its various phases and covering every product, whether raw or manufactured, imported or exported, is always received with great interest. On this account we welcome the report which gives the conditions and prospects of British trade in India at the close of the war, written by Mr. T. M. Ainscough, O.B.E., H.M. Senior Trade Commissioner in India and Ceylon, recently issued by the Comptroller-General of the Department of Overseas Trade.

The statistics in regard to iron, steel and machinery, together with the recommendations conveyed in the report for increasing our trade with India are the points which will specially appeal to our readers. For example, we find that the United Kingdom, prior to the war supplied nearly 60 per cent. of India's requirements in iron and steel, and annually shipped far over 7,000,000*l.* worth. During the war, however, importers in India have established close connections with American steel producers, and the fact that American shipments to India have increased no less than 800 per cent. in the four years of war shows that we shall have to adopt more strenuous methods if we are to regain our normal share of this particular trade.

The recommendations referred to are that the British steel producers should take steps to form one or more export selling organisations of non-competing manufacturers, and should open their own offices in Calcutta and Bombay for the sale of their products and from stock in the case of articles in constant demand. Only by this means will they be able to meet the enhanced competition from the United States and also receive their fair share of Government orders. Combinations and amalgamations among steel producers are the order of the day throughout the world, and a necessary corollary is the formation of such organisations for selling purposes. It will be remembered that advice having a similar bearing was given in Messrs. Bolling and Lowe's last annual review, of which we gave an abstract in a former issue. The smaller manufacturers of standardised products, such as tees, angles, &c., would probably be well advised, says the Trade Commissioner, to continue to deal with the many old-established London and Glasgow metal exporters, who usually have connections in the principal Indian centres, and who would be able to amalgamate the multiplicity of small bazaar indents into one substantial order and would furnish cash against documents in London. The British metal export merchant having an established trade with the Indian bazaars would do well to maintain a resident representative on the spot, for the tendency all over India is for the buyer to prefer personal dealings with the actual seller rather than to conduct his business by letter or cable with a buying agent in the United Kingdom.

On the other hand, the report calls attention to the competition of Indian manufacturers of iron and steel. In a few years, there will probably be at least four such manufacturers, namely the Tata Company which commenced producing steel in 1913; the Bengal Iron and Steel Company; the Indian Iron and Steel Company and Messrs. Bird and Company. The discovery of a mountain range of iron ore in Singhbhum, Orissa, is an epoch-making one in the history of the Indian iron and steel industry. With this iron ore deposit as a starting point, subsequent prospecting has led to tracing what appears to be a range of iron ore forming a definite geological stratum, in the Dharwars of Singhbhum. The iron ore range, rising to about 2,500 ft. above the sea level, runs almost continuously for 40 miles in a S.S.W. direction, and it has been largely staked out by these four iron and steel companies. One bed shows a body of high-grade hematite about 400 ft. in thickness and 1,300 ft. in length, having a steep dip down which the deposit has been exposed by quarrying operations for some 500 ft. The ore layer plunges to an unknown depth. The ore it contains averages on analysis, iron 64 per cent., silica 3 per cent., manganese 0·06 per cent., and phosphorus 0·05 per cent. At one place, on the concessions of the Tata Company, a ravine cutting across the iron range shows a continuous thickness of some 700 ft. of hematite containing over 60 per cent. of iron. If the results of future development work confirm the present ideas as to the magnitude of this discovery, it is claimed that India may be regarded as provided with reserves of high-grade iron ore commensurate with as large an expansion of her iron and steel trade as may be justified by the requirements not only of India, but of surrounding Eastern markets.

An essential condition for this is the availability in close proximity to the iron ore deposits of coal measures yielding a fuel of the required quality. The report, however, does not enter into any detail with reference to this essential question. It speaks of the occurrence of vast deposits of limestone in Gangpur State and makes a passing reference to the proximity of the most important coalfields of India. But an idea of the extent of India's coal production may be gathered from figures given in another section of the work we are thus briefly analysing. The coal, coke and patent fuel imports into India for the year 1913–1914 were a total of

559,190 tons, the main suppliers being the United Kingdom 174,997 tons, Natal 118,532 tons, Australia 47,329 tons, and Portuguese East Africa 70,333 tons. The proportion of coke and patent fuel in these figures is so low that it is practically negligible. In the year 1917–1918, the total fuel imported was only 24,789 tons (United Kingdom 4,771 tons, Natal 1,639 tons, Australia 8,102 tons, and Portuguese East Africa 8,457 tons). This shows a falling-off in coal imports of 534,401 tons. The whole strain of supplying India's requirements, following upon the war, was thrown upon the Bengal and Bihar collieries.

Coal-mining machinery has, so far, been very little used in Indian collieries owing to the abundant supply of cheap labour and to the fact that the workings have been at comparatively shallow levels, affording easy access to the seams. In view, however, of India's future need for a much greater output of coal to supply her industries, some of the leading firms are proposing to put down electrically-driven coal-cutting machinery and in this respect the prospects are said to be very promising.

The smelting of iron ore with coke is bound to centre at Singhbhum, but the production of electric steel and ferro-alloys in Mysore is receiving attention, and should a large hydro-electric scheme near the West Coast be followed up, as is intended, the question of smelting the hematite ores of Goa, Portuguese India, would also be worth considering.

The treatment in India of other metals—aluminium, lead, zinc, &c.—is also dealt with. The Bengal Brass Company, Limited, was formed in 1918 by Messrs. Howeson Brothers to manufacture all kinds of brass and gunmetal work. They import their spelter from Australia and their copper from Japan; their machinery was largely made in Calcutta and they are now producing water and gas fittings of all kinds. They propose to import a complete wire-drawing plant. Brass castings are also made in Calcutta by McLeod and Co., Limited, and by the Britannia Brass and Iron Company. India does not yet produce all the tin required for her consumption; she is, however, likely to do so in future from her own deposits in Burma, and in any case she can always satisfy her requirements from her neighbour, the Federated Malay States, which is responsible for about 43 per cent. of the world's output of this metal. The proposed installation of mills for rolling steel sheets at Sakchi will render possible the manufacture of tinplate, and tinplate works are to form one of the series of subsidiary industries at the latter place. Numerous deposits of manganese, chrome and wolfram occur in India, and as soon as cheap supplies of electric power become available, the possibility of producing ferro-manganese, ferro-chrome and ferro-tungsten in electric furnaces in India will be seriously considered. The following figures of output of some of India's metallurgical products will be found of interest; they apply to the year 1917. Gold 574,293 oz., platinum 3·8 oz., silver 1,581,838 oz., lead 16,962 tons, tin metal 141 tons, and tin ore 666 tons, pig-iron 248,132 tons, steel 114,027 tons, ferro-manganese 1,475 tons.

In regard to machinery, 89 per cent. of that imported into India before the war was obtained from the United Kingdom, and competition was confined to a certain amount of flour and rice-milling machinery, electrical plant, &c., derived from Germany, and relatively small quantities of mining and oil-crushing machinery purchased from the United States. British engineering firms are advised to open their own offices and selling organisations on the field, in those cases where the trade to be gained warrants the expense, and, in other instances, to form group-selling organisations in conjunction with other manufacturers who trade in non-competing lines, the group opening its own offices in India. The reasons on which these recommendations are based are explained at length by the Commissioner, and he adds that firms who contend that they do not need to leave London to secure Indian orders should bear well in mind that some of the leading industrialists and managing agents in India are opening New York buying offices with a view to develop their American connections and to place New York in competition with London. The report gives useful data on business in prime movers, agricultural and other machinery, boilers, motor cars, &c., all of which will be found of great interest by British manufacturers and merchants. In the matter of railway rolling-stock and plant, British manufacturers had a firm hold on the trade before the war, and also during 1917–1918 when imports had fallen to a very low figure. But competition will become increasingly severe in the future in regard to railway material from India herself, for considerable contracts for wagons have already been awarded locally, and more than one prominent engineering firm in India is paying close attention to this trade. Moreover, the local railway workshops have been extended since 1915, when they employed 107,000 men, with the result that the railways themselves are manufacturing more and more of their requirements.

The report, which is the first to be prepared by a trade commissioner in India, covers also a large number of industries which are outside our province. It deals extensively with textiles, chemicals, dyestuffs, glassware, hardware, &c., and refers also to the prospects for the sale of Canadian products and manufactures in India. It will repay careful reading by all British manufacturers and merchants who trade with the Far East.

## THE SERVICE OF A TECHNICAL SOCIETY.

At a time when some of our technical societies are branching out in new and untried directions, it may be of interest to notice what is happening in this way in the United States. In doing so we must remember the difference in the physical characteristics of the countries served. The greater distances of the American Continent make it less easy to work in one chief centre. In fact, the conditions there are more nearly represented by the British Empire than by the United Kingdom.

If we may rely on the trend of opinion expressed at local or section meetings of the American Society of Civil Engineers, which has a membership of about 9,000, there is a general consensus in support of the proposals brought forward by a development committee of the society which sat last year with the object of defining lines of possible future policy. The report which this committee has submitted deals not only with the internal affairs of the society, but also with its external relations with other kindred bodies, and with matters of national importance.

Broadly speaking, if we deal with the internal affairs first the report favours decentralised activities. That is to say, it proposes a policy of building up strong local sections, instead as hitherto concentrating in New York. The central organisation would be retained in a modified form, but it is proposed to abolish the fortnightly meetings. In lieu the local sections are to hold not less than four meetings per annum, while the half-yearly meetings of the parent body might, it is suggested, be supplemented by two others, making four large meetings held in succession in various parts of the country, in co-operation with the local sections. The idea evidently is that a larger number of members would benefit from these two kinds of meetings than can possibly do so from the meetings held in New York, which can only be conveniently attended by a few. Further, of course, more members would make an effort to attend a meeting of some days' duration, not too far away, when a long journey for a single evening would be out of the question. There would, in addition, be an annual meeting and an annual convention, at both of which technical matters would form a prominent feature.

It is proposed that every member be assigned to a local section, and shall affiliate with members of allied professions for co-operation in public matters. The local sections would combine in geographical districts and each section would have its representative on a district board. Representatives of the local sections would also meet at the annual conference and discuss matters affecting the welfare of the whole body, and would elect the chief officers, the delegates having voting powers in proportion to the strength of their sections.

There is evidently a feeling that some of the conventions organised by these large American bodies are verging on the frivolous, for it is suggested that sociability should not be allowed to interfere with the more important duties of the society; and again we find that no excursions should be scheduled for the first day. Apart from the usual business at the annual meeting, and the presentation of reports of technical and other committees, &c., it is proposed that there should be a carefully-planned programme of addresses and discussions on technical and social problems of national importance. It is felt that the voluntary haphazard system of papers is unsatisfactory and that definite and logical programmes should be arranged. Descriptive papers should be brief, and more attention paid to the lessons of successes and failures, while financial, administrative and other factors controlling the engineering problems dealt with, should be given more attention. These suggestions might be noted with advantage by prospective authors over here.

The portion of the report dealing with external relations was drawn up in conjunction with committees appointed by the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers. This joint report recommends a national engineering organisation, embodying a national council and local affiliations, with possibly State councils as a kind of go-between. The formation of these would naturally strengthen local action in public matters. The object of this organisation is to advance the influence of engineers in national affairs, to render the nation enhanced service by unity of action, and to provide machinery for prompt and united action on matters affecting the profession, such as the licensing of engineers, conservation of national resources, public works, education, industrial relations, and so on. These, of course, are laudable objects. The difficulty will be experienced when actual work is attempted. It is a great deal easier to make such suggestions than to produce definite recommendations of material value. However, there are plenty of directions in which authoritative guidance or ruling would be advantageous. The actual form of the proposed national organisation is to some extent vague, but the local or affiliated bodies would be represented on it. The National Council would hold meetings once a year or so, and there would be an executive board of not more than 30, with salaried officials and headquarters.

The State is, so to speak, the national unit of organisation, and the plans proposed in this way fall in with the national arrangement, in which the States legislate for themselves, while the Federal Government endeavours to get them to work more or less in harmony for the good of the whole country. The local affiliations are intended to be strong enough to make their influence felt in matters within the individual States, while the National Council should develop into an authority of sufficient weight to make its influence felt in Federal questions. To make the local bodies strong the co-operation of the four leading societies is advocated, and also affiliation with institutions of kindred and allied professions. The co-operation of the four founder-bodies is to extend to all professional matters, including standardisation, employment, &c. Joint meetings should be held, while industrial relations and educational movements, &c., should also form the subject for co-operation with affiliated bodies. A national code of ethics for the profession is suggested by the committee, which, however, consists mainly of an elaboration of one of the clauses adopted, which reads as follows: "The right relation of the engineer to his profession is succinctly embodied in the golden rule 'All things whatsoever ye would that men should do to you, do ye even so to them.'" With the official endorsement of such a principle, which is as sound now as when it was enunciated, the popular view based on the parody "Do the other man as you think he would do you, but do him first," must needs be revised. We need hardly say that the latter has hardly been taken seriously as the real motive of responsible men among our friends across the Atlantic.

Port of Preston.—The Corporation of Preston have issued a handbook, giving a plan of the port, together with complete information on the accommodation available, the trade in various goods and products, the traffic, rates and charges, tide tables, &c.

## NOTES.

### CONCRETE IN HOUSE BUILDING.

A GOOD deal of space at the Ideal Home Exhibition which opened at Olympia on the 4th inst., and will remain open till the 25th, is naturally devoted to the design and building of small houses. With the designs we are not much concerned, and it will suffice with regard to construction to state that the systems adopted range from wooden houses to small buildings of steel framing and concrete block or reinforced concrete wall filling. Various systems of making concrete blocks are exhibited in operation, including solid and hollow and shaped blocks of various types and sizes. A feature of the exhibition is the number of systems of hollow wall construction shown. These do not merely include hollow concrete blocks, but various types of slab blocks designed with lugs or ribs. These blocks are arranged back to back, the slab faces forming the front and back of the walls, while the vertical ribs on the inside interlock or bond. The remainder of the exhibition comprises possible items of interest to our readers such as small electric lighting sets, water-softening plant and applications of gas and electricity to domestic purposes. The greater part is, however, of general rather than technical interest.

### RAW MATERIALS FOR GERMANY.

In his presidential address to the Conference of Manufacturers and Producers which met at the Kingsway Hall on Tuesday last, Mr. W. Peter Rylands drew attention to the importance of supplying the Continental Powers with the raw materials necessary for the rehabilitation of their industries. Amongst these nations he said it was necessary to include Germany, though he admitted that this latter proposal might not unnaturally, be viewed with considerable suspicion. In this, no doubt Mr. Rylands is correct, and the situation is not eased by the present attitude of that country. Most of us, no doubt, would be prepared to forget that Dr. Helfferich, in introducing one of the German war budgets, announced that there was no necessity for imposing any special war taxation, since for many decades to come Germany would be surrounded by a circle of conquered countries, yielding her yearly an enormous tribute. We are not a vindictive nation, and should Germany even now show a disposition to make amends for her crimes, there would be little difficulty in getting support not only for supplying her with the raw materials necessary for the re-establishment of her industries, but also for modifying such clauses of the Peace Treaty as a few years experience should prove to be unreasonable. Whilst, however, that country refuses to keep her word and hand over the criminals who shot down helpless sailors in pursuance of the policy that it was desirable that certain ships should be *spurlos versenkt* and committed other even worse atrocities, the strong economic arguments brought forward by Mr. Rylands are unlikely to be accorded their due weight. As instancing present conditions in Germany, partly due, it may be added, to the belief that war taxation was unnecessary, owing to the tribute to be extorted on its conclusion, pig-iron is now, Mr. Rylands said, quoted in Germany at 1,700 marks per ton, as compared with a pre-war price of about 80 marks per ton. Her other industries are largely held up by the impossibility of acquiring essential raw materials from abroad, and national bankruptcy stares her in the face. This we may well wish to avert, but the issue rests with Germany herself. An honest endeavour to atone for the past will certainly not fail to find a response here and on the part of our allies.

### PHOTOGRAPHY WITH SPECTACLE LENSES.

In order to take portraits indoors with instantaneous exposures it is necessary to employ a lens capable of working at a large aperture. A portrait lens with a working aperture of *f*/3·6 or *f*/4 is usually employed by professional photographers, but this is, of course, a very costly piece of apparatus, beyond the reach of most amateurs, and in any case the expense is hardly justified for occasional use. From a communication by Mr. H. D'A. Power, appearing in a recent issue of *Camera Craft*, it appears that quite good results can be obtained in the above-mentioned class of work by means of an ordinary "pebble" spectacle lens that could be purchased for a few shillings in pre-war times. Mr. Power used a lens having a focal length of 4½ in. with an aperture of *f*/3, and his experience with this lens he considers sufficiently satisfactory to justify the more general use of lenses of this type. In addition to its obvious advantage in the matter of cost, the simple lens is able to transmit a considerably greater amount of light than a lens of usual construction, owing to the fact that the number of surfaces from which the light can be reflected is reduced to a minimum in the former. On the other hand a certain amount of linear distortion, which causes straight lines near the edge of the plate to appear curved, is unavoidable in the simple lens. This, however, is reduced to a minimum by using a lens of the meniscus form, i.e., having one surface convex and the other concave, and mounting it so that the convex surface faces towards the plate. The use of rock crystal, or pebble as it is usually called in the trade, for a simple lens, has the great advantage over glass, that the visual and photographic foci are practically identical in the former, the distance between them only amounting to about one four-hundredth of the focal length. With optical glass the distance between the foci is ten times as great, and would have to be allowed for by racking back the lens after focussing, so that there is considerable difficulty in obtaining good definition. It would be interesting to know the size of plate covered by the lens used by Mr. Power when working at full aperture, but this unfortunately is not mentioned. If a diaphragm is used it should be placed about one-fourth of the focal length in front of the lens, and when working at full aperture a lens shade should be employed.

### AMMONIA SYNTHESIS AT 1,000 ATMOSPHERES.

IN his new synthetic ammonia process, Georges Claude, of Paris, well known for his successful researches on the isolation of the rare gases, works with pressures of 1,000 atmospheres. The advantages of such high pressures at high temperatures are not very obvious, considering the difficulties involved, and that Haber is believed to effect the combination of nitrogen and hydrogen (which refuse to interact at ordinary pressures and temperatures) at 200 atmospheres and a temperature of about 600 deg. C. Claude, however, keeps to the same temperature, and he has explained the advantages of the very high pressures in two communications presented to the Académie des Sciences on December 1 and January 19 last. He does so by referring to the Haber process. In the first instance the percentages of combination to be realised at very high pressures could not be deduced from Haber's equilibrium formula which does not admit of extrapolation to much higher pressures. Claude, therefore, experimented with mixtures of 3 volumes of hydrogen and 1 volume of nitrogen, free of oxygen, but not rigorously dried. He found that the concentration of ammonia in the gas mixture could be raised, finally to 25 per cent., as the pressures were raised in steps of 200 atmospheres, finally to 1,000 atmospheres. His experiments were not sufficiently exact for the determination of the percentages of ammonia in actual equilibrium with the nitrogen and hydrogen at the respective pressures, but were sufficiently concordant for his purposes. The concentration percentage of 25 would correspond to a combination ratio of 40 per cent., and the increased combination ratio implies other advantages. According to Claude, Haber has to send his gas mixture many times through the catalyser and, as 80 per cent. or 90 per cent. of the mixture leaves his catalyser uncombined, he has to deal many times with large gas volumes, whose recondensation requires additional power, finally only to realise a maximum combination ratio of 13·5 per cent. Claude claims to attain his high ratio by sending his mixture only three times through his catalyser, and as the volumes are not large, owing to the initial high compression, and are considerably reduced further by each passage through the catalyser, no additional power is required. Claude's catalyser is described as a tube, 10 cm. long, 8 mm. in diameter, filled with a fine-grained catalyst. Working with 100 cub. m. of gas per litre of catalyser capacity per hour, at 600 deg. C., the above-mentioned combination ratio of 40 per cent. would yield 6 grammes of ammonia of 25 per cent. per gramme of catalyst, per hour, whilst Haber, it is stated, obtains only 0·5 gramme of an ammonia of 6 per cent. The further advantages are connected with the removal and fixation of the ammonia produced. At the relatively low pressure of Haber only part of the ammonia is directly taken up by water unless the whole gas mixture is cooled to — 40 deg., or the water is itself injected into the apparatus at 200 atmospheres. Claude obtains part of his ammonia in the liquid condition, and bases his fixation upon the Schreib process to which we referred in a recent Note on Industrial Synthesis of Ammonia.* Proposing to utilise his ammonia largely as fertiliser and to bind it by hydrochloric acid (not by sulphuric acid), he gains both ammonium chloride and bicarbonate of sodium by passing alternately gaseous ammonia and carbon dioxide through a neutral sodium carbonate solution at + 5 deg. Without giving any particulars as to process or apparatus, he points out that his synthesis could be adopted in industrial plants where hydrogen forms a by-product. As regards temperature, he confines himself with Haber to the limits 500 deg. and 700 deg., because the velocity of reaction is too small below 500 deg., and the ammonia concentration too small below 700 deg. In his first paper he admits that special measures have to be taken to remove the great amount of heat evolved by the reaction; but this is the only reference he makes to his technical difficulties.

### THE GERMAN CHEMICAL INDUSTRIES.

The views which we have on various occasions expressed as to the causes of the German predominance in manufacturing chemistry are strikingly confirmed by the conclusions arrived at by the British Mission appointed to report on the Chemical Industry in Germany. This Mission consisted of 20 members of the Association of British Chemical Manufacturers, accompanied by a military representative and by four delegates representing the Department for Overseas Trade, the Board of Trade, the Local Government Board and certain Canadian interests. A long abstract from the report was published in *The Times* on Monday last. The conclusion reached is that the success obtained in this field by German firms was due simply to intelligent industry and to the trust reposed by the manufacturers in their scientific advisers, and the great and admirable courage shown in financing the work of these experts. It is in no way dependent on any special ability which the Germans possess. We may note in illustration of this that although the Germans were the first to employ in warfare the mustard gas originally discovered by Guthrie in 1861, their methods of manufacture were so poor that in a very short time our own chemists had "beaten them to a frazzle" in the matter of producing this gas in quantity, and relatively inexpensively. It was long a matter for surprise in military circles that the Germans failed to exploit the great advantage they had gained by being the first to use this gas; and it was only near the end of the war that it was discovered to be due to the crude methods of production adopted. The yield obtained was extraordinarily poor, whilst our own chemists succeeded in obtaining a yield very nearly equal to the theoretical. The committee report, however, that although, as in the instance already mentioned, greater intelligence has often been exhibited in English works, the German, in spite of inferior methods, often succeeds in obtaining good results by sheer dogged perseverance and conscientious attention to detail. He is, moreover, it is noted, prepared to begin on a small scale and gradually extend his operations. This is in accord with the general experience that any undertaking of a novel character started on a large scale seldom or never succeeds. The German chemical firms have, moreover, recognised that a man who had sufficient ability to do good scientific work was probably better fitted than most, for advising on questions of business or administration. Their experts accordingly have been treated rather as partners than as salaried servants, and as a consequence the methods and outlook successful in the laboratory

* ENGINEERING, August 5, 1919, page 135.

have been adapted to the solution of business difficulties. As one consequence the Mission report that scientific method is found to underlie all that appertains to the industry. This is, it is stated, true not merely of the laboratory and factory, but of every side of business activity. Internecine competition has been eliminated by close co-operation between the large firms. If one can make a certain product better than another, this particular factory supplies the other firms in the combine with the commodity in question, and it is sold by these firms in their own name. As for foreign competition, this is met by undercutting the adventurous outlander until he is driven out of business, a large campaign fund having been accumulated to this end. Confirmation of this part of the report, is afforded by the statement made some four years ago at a meeting of the Institute of Metals, by Mr. Dewrance. As the result of certain experiments, Mr. Dewrance had, he said, commenced to manufacture a certain metallic salt, and did so successfully for some years. The Germans then commenced to make the salt and compete with him, and finally reduced the price to below the actual cost of production, thus causing Mr. Dewrance to close down his works. Within a fortnight of this event the price was doubled, and afterwards raised twelvefold. During the whole of the period of competition Mr. Dewrance was able to ascertain that his own methods of manufacture were superior in every respect to those of his competitors. But although he could make the product more cheaply, the financial resources at the back of the German firm were too much for him, and his rivals then recouped their temporary losses by raising and maintaining the price to English buyers at a point far above that at which the commodity could be profitably manufactured here.

### The United States Naval Communication Service.

Before the 1919 British Association meeting at Bournemouth the general public was hardly in a position to form a clear idea of the amazing development which radiotelegraphy had taken in this country during the war, mainly owing to the efficiency of the thermoionic valve. What has been done in this field, in the United States Navy, was explained by Captain W. Bryant, U.S.N., Acting-Director of the Naval Communication Service, in a lecture delivered at Philadelphia last October before a joint meeting of the Franklin Institute and the American Institute of Electrical Engineers. When the "Naval Radio Service" was established in 1912, we see from this lecture, the equipment of the coast stations was good, but the stations were not connected up to the best advantage. All naval communication activities, telegraph, telephone, cable, radio, were hence combined in the Naval Communication Service, which was placed directly under the chief of naval operations. As an experiment all the naval stations of the United States were, in May, 1916, connected up to a central telephone switchboard in the Navy Department, and by these means Mare Island, California, could talk to the New Hampshire, lying off the Virginia Capes. By January 1, 1917, the service operated 55 radio stations; but naval vessels could only receive one message at the time, there were only 1,031 operators in the Navy, not all the merchant vessels were fitted with radio apparatus, and some of the equipment was poor. With the war came development by leaps and bounds. The Navy took over 59 commercial radio stations, built 67 stations and closed all private stations. The ship equipments were perfected enabling a ship to receive four messages simultaneously and to transmit three; the whole merchant fleet was provided with apparatus and operators. The operators were trained at Harvard College, which, in June, 1917, had 350 students under instruction, and by armistice time 3,400 students; altogether 7,000 operators completed their training there. Naval officers were also trained. When the submarine danger threatened the Navy were cautioned against using their apparatus, and instructed to listen all day; merchant vessels had to listen for orders during certain hours. The Shipping Information Service later published confidential daily bulletins on ship movements and safe routes. Meanwhile communications with Europe was established, the stations at New Brunswick, Annapolis, Tuckerton and Sayville transmitting, and Chatham and Belmar receiving; later Bar Harbour, in Maine, was alone equipped for receiving. Several thousand words could then be handled per hour. Europe transmitted from Carnarvon (Wales), Rome (Italy), Lyons (France); Lyons alone of these three stations maintained a satisfactory service. The United States built a radio station of their own, of 1,000-kw. power, at Bordeaux, France. Radio companies' stations were created to inform ships of their position and to listen to the enemy's signals; there were 58 of these stations finally. A ship sending Q T E or Q T F indicated that it wished to be informed of its bearings or position; the station supervisor then instructed the stations which wave-length to use in reply to the dashes sent out by the ship; the signals received by five stations mostly enabled the supervisor to calculate the position; if not, the ship was asked to repeat signalling. Records of all the signals were kept, and much useful information obtained by their subsequent study. Signals were also given to help ships to make port in foggy and thick weather. Overhead antennæ were replaced by balanced loops, underground wires and low horizontal wiring; submarines could finally receive from shore stations, ships afloat and aircraft overhead, when submerged at a depth of 20 ft. The life of valves was prolonged to 5,000 hours. In the year ending April 6, 1919, the Navy Department alone handled 1,000,000 despatches of about 30 words each. The totals handled by the Navy Communication Service during the last year (the same period seems to be meant) amounted to over 71,000,000 words, of which about 1,600,000 were coastal radio messages, over 16,000,000 high-power radio messages, transatlantic or continental, and 153,500,000 messages by leased wire, Postal or Western Union Company. The service was very hard also during demobilisation when some of the larger transports handled 15,000 messages in a single month, facilities being granted to the troops for communicating with their friends.

## NOTES ON NEW BOOKS.

The average engineer will, as a rule, find a good deal of difficulty in getting hold of any satisfactory information regarding foundations for machinery. It is a subject on which comparatively little has been written and for which most young engineers have to rely upon an all too brief experience. It is really surprising under the circumstances that failures are not more frequent. Although by no means exhaustive, a little book just published by the Technical Publishing Company, Limited, at the price of 3s., entitled "*Foundations for Machinery*," by Henry Adams, is the first to our knowledge to give any reasonable information on the matter. It will at least draw attention to many of the facts to be borne in mind when coming to decisions. It is to be regretted that, in proportioning foundations, the subject of rigidity is dismissed with little more than the remark that fast-running machines often require foundations designed to resist vibration, rather than proportional to dead load. This is a branch of the subject in which a good deal of practical information might have been given. In fact, the whole book would have been greatly enhanced in value by the discussion of a larger number of successes and failures for various types and sizes of machines. It is unfortunate that Fig. 19 should show a boring rig driving a filter point, when the subject dealt with there is subsoil data obtained from bores. Perhaps these matters will receive further attention in future editions. The book as it is promises to be useful, but it might well form the skeleton for a much more comprehensive work.

We are inclined to doubt the necessity for including tables of logarithms, trigonometrical ratios, areas and circumferences of circles, squares and roots, metric equivalents, &c., in almost every technical reference book issued. Usually a special table book is far more convenient to use when such quantities are required for calculations, and as most technicians need several reference books in connection with their work the omission of mathematical tables from all of them should considerably reduce the total cost in these days of expensive printing. However, those who expect to find such tables will not be disappointed if they acquire Mr. A. W. Judge's "*Handbook of Modern Aeronautics*," in which some 70 pages are devoted to the kind of matter to which we have been referring. They will also find extensive tables of screw threads, wire gauges, &c., which they probably already possess in some form or other. Weight estimates and tables for aeroplane design, strength of materials, aeroplane fittings, aeroplane design and performances, stability and control of aeroplanes, meteorology, aerial navigation, aero. engines and airscrews, are all very fully dealt with, and these sections will certainly be extremely useful to manufacturers and designers of airoraft, as well as to draughtsmen and students of aeronautics. There are also sections on mathematics and the principles of mechanics that may be useful to refresh the memory, and an extensive section on aerodynamics is also included, though some of the matter in this latter section seems rather out of date. The latest British wing section of which the properties are given, for instance, appears to be R.A.F. 6, though some American sections of later date are dealt with. In this respect, however, it is probable that the author's choice of matter was limited by the censorship in force while the work was in preparation, and on this account an improvement in the next edition may be confidently anticipated. The price of the book is 30s. net, and it is published by The Library Press, Limited, 26, Portugal-street, London, W.C. 2.

Pockets distinctly larger than usual would be required to contain some of the so-called pocket books issued in recent years. We are led to this remark by the contemplation of "*The Aviation Pocket Book for 1919–20*," by Mr. R. Borlase Matthews, which has recently been published by Messrs. Crosby Lockwood and Son, of 7, Stationers' Hall-court, London, E.C. 4, at the price of 12*s.* 6*d.* net. This is a good-sized volume, measuring 5½ in. by 8 in., and over 1 in. in thickness, which we were quite unable to get into any of our pockets. However, as such publications are rarely, if ever, carried in the pocket the objection is by no means serious, and in this particular case it is nullified by the fact that arrangements have been made by which any, or all, of the pages can be extracted and filed in a loose-leaf book. The method adopted, which has been patented by the author, is known as the de-tachable da-ta system, and it appears to have much to recommend it for publications of this class. It will undoubtedly be a considerable convenience to individual users to extract the particular notes and data they require and file them suitably for ready reference. Useful suggestions to this end are contained in the book. Another new feature with the present work is the adoption of the decimal system of classification for the matter. The main divisions of the book are devoted to air pressure and resistance, airscrews, structural design of aeroplanes, aeroplane engines, navigation and signalling, instruments, alignment and rigging, and a great mass of useful information of a theoretical and practical nature is given on these and other cognate subjects. Much of the matter has been re-written and brought up to date from previous editions, and, although a considerable amount of new matter has been included, it must be remembered that much of the revision work was completed before the end of the war. However, it certainly forms a useful work of reference for aeroplane designers and pilots, and, in fact, for all interested in aeronautical matters. As suggestions for the improvement of future editions are invited we would express the opinion that in any book which is intended to be referred to frequently, and often hurriedly, it is highly desirable that the edges of the pages should be machine cut. This has not been done in the volume now before us, so that it is probable that, in the aggregate, a great deal of time will be wasted in fumbling with pages that have been cut by some quite unsuitable implement used as a paper knife.

That pyrometry must now be regarded as part of the ordinary business of the mechanical engineer is to be inferred from the fact that a new section devoted to this subject has been included in the latest edition of *The Practical Engineer Mechanical Pocket Book and Diary*. The engineer will not, however, be able to confine his attention, as the author of this section has done, to pyrometers of the radiation, optical and calorimetric types; he must also consider the quite equally important thermo-couple and resistance types. Instruments of these latter types are, apparently, dealt with in an electrical pocket book issued by the same publishers, but, in our view, it is undesirable, and rather illogical, to divide the subject in this way. Some users may be puzzled by an illustration showing some seger cones in different states of collapse, as the illustration appears without any title, and with no explanation in the text, as far as we could discover. We would also call the editor's attention to the fact that there are now two sections numbered XV, and that the section on pyrometry has been omitted from the table of contents. On the whole, however, the pocket book is an extremely useful publication, and the fact that it has reached its thirty-second year of issue is a clear indication that it is appreciated by engineers. The subjects dealt with include steam engines and

boilers, steam turbines, condensers, internal combustion engines, air compressors, machine tools, power transmission, and many others. The information has been kept well up to date, and new notes have been added in connection with boiler chimneys, chains, &c. The work is issued by The Technical Publishing Company, Limited, 1, Gough Square, Fleet Street, London, E.C. 4, and it is sold at the remarkably low price of 1*s.* 6*d.* net, bound in cloth covers. It is also sold in a better binding at 2*s.* net, and the home and foreign postage is 6*d.* in each case.

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A simple and inexpensive handbook dealing with the problems involved in the erection, repairs and handling of motor vehicles should find a ready sale among the large and increasing section of the general public that now takes an intelligent interest in matters of this kind, as well as among motor-car owners, garage proprietors, drivers and others more directly concerned. Such a handbook was originally issued by Messrs. Cassell and Co., Limited, in 1913, since which time it has been revised and reprinted on several occasions. A new edition, which has been largely re-written and brought quite up to date, has recently made its appearance, and the authors—Mr. George W. Watson, M.I.Mech.E., M.I.A.E., and Mr. F. Heron Rogers, M.I.Mech.E.—have certainly succeeded in collecting a great quantity of data and useful information in the 260 odd pages which comprise the volume. The construction and working of the engine is first dealt with very thoroughly, and details such as clutches, gear boxes, differential gears, brakes, steering gears, tyres and wheels, accessories, &c., are similarly treated. There are also hints on driving, notes on road resistance, and information on legal and insurance matters. Many of the data given, it may be noted, have been compiled by the authors in the course of their professional work, and have not been published previously. The book is entitled "*The Motor Mechanics' Handbook*," and its price is 3*s.* 6*d.* net.

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It would perhaps be difficult to suggest branches of the applied arts which have advanced more rapidly in recent years than electric welding and oxy-acetylene welding. Both processes gained status in the war, and although some of the more extreme manifestations of their possibilities which the war encouraged are little likely to be paralleled in the early days of peace, the methods have by now won for themselves a definite place in shop routine. They have established their ability to tackle certain classes of work in an economical and satisfactory way. That both methods are destined to an advance in usefulness, both in extent and intent, there is no question, and, although they are now largely in the hands of specialist firms, the general shop manager of the not distant future is likely to find that he is expected to be able to apply them. Not only this supposititious manager, but others, both engineers and the "semi-skilled," are likely to find interest and profit in a small book on "*Practical Electric Welding*," written by Mr. H. Bevan Smith, and recently published by Messrs. E. and F. N. Spon, at 7*s.* 6*d.* net. Both the aim and fulfilment of the author's intentions are well expressed in the title. The book is essentially practical and covers a very adequate summary of the methods and materials of electric welding. It may be described as elementary in that it contains neither chemistry nor mathematics, but it does contain the practical information that a tyro in electric welding is in need of.

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There was always a considerable proportion of motor-car owners who preferred to carry out their own repair work, as far as possible, and doubtless the proportion has increased in recent years owing to the fact that many persons have had their mechanical instincts awakened or developed by reason of their occupations during the war. To such we recommend a little book entitled "*Motor Repair Work*," the third edition of which has recently been published by the Temple Press, Limited, 7 to 15, Rosebery-avenue, London, E.C. 1, at the price of 1*s.* 9*d.* net. The book explains in simple language, with profuse illustrations, how operations ranging from the mending of a puncture to the complete overhaul and adjustment of a car, can be carried out by an owner-driver, and incidentally it should be of material assistance to him in understanding the construction of the machine he uses.

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The amount of attention being devoted to the improvement of the roads of this country will probably result in a cordial welcome being given to a very thorough American handbook on this subject. This book, entitled the "*American Highway Engineer's Handbook*" (Chapman and Hall; 23*s.* net), is the most comprehensive thing of its kind. Primarily, of course, it deals with the subject from the American point of view, but the mass of information and data collected in its sixteen hundred odd pages contains a great deal which stands good for all countries, and will be found of value wherever roads have to be put in a position to stand up to modern heavy traffic. It is a reference book of highway engineering, dealing with the problem from surveying, alignment and planning at one end, through materials and construction, to administration, sanitation, &c., at the other. The volume is divided into 29 sections, each of which is dealt with by an authority of considerable standing in the country of its origin.

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## "WATER-COOLED TURBO-ALTERNATORS."

To the Editor of Engineering.

Sir,—Referring to Mr. Shepherd's letter in the current number of Engineering, I should like to endorse his statement with regard to the reliability of "fusion welding" if the best methods are adopted. There is now no question that by means of electric arc welding it is possible to get results which are comparable with those obtained from mild steel plates of the best quality.

In this connection it may be of interest to record that we have recently had a series of tensile tests carried out on pieces of ship plates welded by our patent process. These tests were carried out at the laboratory of the Royal Naval College, in the presence of representatives of Lloyd's Register. Pieces of plate, ¼ in., ½ in., ¾ in. and 1 in. thick, two of each size, with a butt weld in the middle dressed off flush with the plate, were tested, and in every case the test-pieces fractured in the plate well clear of the weld. The tensile strength of the plates varied from 27·5 tons to 29·9 tons per square inch, and in every case the weld was still stronger.

I would like to add that in selecting plates for these tests, although they were purchased to the ordinary specification of 28 tons to 32 tons per square inch, one plate was found to be seriously laminated and one actually fractured at 18 tons per square inch, and was therefore quite useless for the tests, so that ship plates now on the market were found less reliable than the fusion welds.

It may also be of interest to your readers to record that Mr. Shepherd was one of the first electrical engineers in this country to recognise in a practical manner the usefulness of electric arc welding, as he was responsible for getting a large number of steam-pipe flanges welded *in situ*, these having become defective and unsafe in a very important steam range. This work was carried out to his instructions eight years ago, at a time when few had realised what could be done by this method.

I am, Sir, yours faithfully,

The Anglo-Swedish Electric Welding Company, Limited,
T. M. Aitken, General Manager.

Wood Wharf, Greenwich, London, S.E. 10,
February 10, 1920.

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## FLUID MOTION AND VISCOSITY.

To the Editor of Engineering.

Sir,—My attention has been drawn to Mr. Cowley's interesting paper on "Fluid Motion and Viscosity" (Engineering, January 23, 1920), about which I should like to be allowed to make a few remarks. Mr. Cowley commences by pointing out that a fluid—if we omit all reference to its compressibility—may be "defined," dynamically, by its density and by its kinematic viscosity. From this he continues that "By the dimensional theory it is shown that the interacting force is given by:

$$R = \rho^{\alpha} v^{\beta} f_2 (v\,l/\nu) \quad . \quad . \quad . \quad (2)"$$

This is expressed very elliptically, and, therefore, not perhaps as clearly as it might be; but, further, it is not accurately correct.

By the principle of similitude, and employing dimensional equations, we get, *directly*:

$$[R] = [\rho]^{\alpha} [l]^{\beta - n} [v]^{\beta - n} [\nu]^{n} \quad . \quad . \quad (A)$$

Where the measure of the resistance has *one* dimension in $\rho$, $(2 - n)$ dimensions in length and velocity, respectively, and $n$ dimensions in $\nu$.

From this Lord Rayleigh deduced the equation:

$$R = \rho^{\alpha} v^{\beta} f (\nu/v\,l) \quad . \quad . \quad . \quad (B)$$

This is the same equation that Mr. Cowley employs; but with the argument of the function (for some unexplained reason) *turned upside down*.

Lord Rayleigh always used it as I have given it above; and Dr. Stanton, to whom he communicated it, also always employs it in this form. Why Mr. Cowley should invert this function is certainly not obvious.

I cannot help thinking that it is unfortunate that Lord Rayleigh should have presented the equation in this form, since the $n$ has disappeared; and he says "It is for experiment to determine *the form of this function*."

If we refer back to (A) it is clear that the equation could be put as:

$$R = \rho^{\alpha} v^{\beta} (\nu/v\,l)^{n}.$$

We have here the "form of the function" required, viz., $(\nu/v\,l)^{n}$, where $n$ is *the number of dimensions of* $\nu$.

We can see that $n$ can only have two values; when there is *no viscosity*, $n = 0$; when the resistance is *purely viscous*, or solely dependent on the viscosity, $n = 1$. For all ordinary fluids the equation becomes:

$$R = \rho^{\alpha} v^{\beta} (1 + \nu/v\,l).$$

This is well known, and generally accepted as correct.

If, however, Lord Rayleigh's function be inverted, then, when there is no viscosity, the argument is infinite:

$$f (v\,l/\nu) = f (v\,l/0) = f (\text{infinity}),$$

and the *resistance would be infinite*!

Mr. Cowley also says that "the form of the function *depends upon the shape*, &c." This is not correct—at least, in the form he gives—for if we refer to Lord Rayleigh's paper (*Advis. Comm. Aer.*, 1909–10, page 38), we see, from his equation (B), that when the function depends on the shape, it should be $f (\theta, v/v\,l)$.

When $\nu = v\,l$, the argument of the function $= 1$. It should follow, therefore, that (as experiment shows) the resistance of a fluid may be measured by $R = \rho^{\beta} v^{\alpha}$. At the same time, it must be observed, however, that since $(\nu/v\,l)^{0} = 1$, we have here *an assumption* (made implicitly, it is true), that there is *no viscosity in the fluid*!

Lord Rayleigh also says (A.C.A., 1910–11, page 28), "in all ordinary cases the ratio $\nu/v\,l$, which forms the argument of the function $f$, is exceedingly small. For air, in C.G.S. measure, $\nu = 0{\cdot}13$. If we take $l = 30$ cm. (1 ft.), and $v = 670$ cm. per sec. (15 miles per hour), we have:

$$\nu/v\,l = 6{\cdot}10^{-3} \quad . \quad . \quad . \quad . \quad (E)$$

An error of less than *two-thirds of one-thousandth per cent.* caused by neglecting the resistance due to viscosity, might surely be treated as negligible!

Mr. Cowley makes another exceedingly interesting statement. He says that it has been found that when a strut is first *towed through water*, and next exposed to a current of air in a wind channel, the results obtained are *not strictly comparable* (making due allowance for the different densities of the two fluids); and that these results have caused "even competent authorities on the subject to doubt the above equations." [Those in his paper.]

This "doubt" is very regrettable, since one ought to expect a difference. The principle of similitude is on as firm a foundation as the principle of the conservation of energy, and there is no more reason for doubting the former than the latter. It is a case of "Du Buat's paradox"—*i.e.*, that the resistance of a body *moving in a fluid at rest*, is *not the same* as the resistance which the same body experiences *when fixed in a fluid*, flowing past it *at the same relative speed*.

This is *a fact* which I have pointed out on several occasions; but which has always been disputed. It is, therefore, exceedingly satisfactory to know that this fact has now been "discovered" at the National Physical Laboratory, since it is of the first importance when studying the resistance exerted by fluids.

There is no danger of this discovery affecting "the whole foundation of wind-channel research." It is necessary, however, to be careful only to make *logical deductions* from the results obtained from such method of research.

"Du Buat's paradox" is very frequently met when studying hydro-mechanics; it is easily explainable by ordinary "Newtonian mechanics"; and, some day, its truth will be accepted, since it is, really, only prejudice which prevents such from being the case to-day.

Yours faithfully,

February 10, 1920. R. de Villamil.

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Non-Ferrous Metals.—The following were the stocks (exclusive of old metal and scrap) in this country of soft pig lead and refined spelter in the possession of the Minister of Munitions on the 1st inst.: Soft pig lead, 47,348 tons; refined spelter, 8,697 tons.

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The Society of Engineers (Incorporated).—The inaugural meeting of the Society of Engineers (Incorporated), was held in the apartments of the Geological Society, Burlington House, on the 9th inst., when Mr. Burnard Geen, president for the year 1920, delivered his presidential address. After referring to the work and utility of the society and the education and training of engineers, the president dealt with his main theme, "A Few Aspects of the Present Position of Engineering." The premiums awarded for papers read during the year 1919 were presented as follows:—President's gold medal to Mr. Alfred S. E. Ackermann, B.Sc.(Eng.); Bessemer premium to Mr. C. O. Bannister, F.I.C., Assoc.R.S.M.; Nursey premium to Professor James Young; Society's premium to Captain M. E. de Jarny, Croix de Guerre.

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Portable Concrete Wall Mould.—An ingenious type of form used for constructing concrete walls is shown at the Ideal Home Exhibition by the Scruty-Harkness Building Mould Company, Harlow, Essex. This mould or form builds a continuous wall, the form being held in place by the last section of the wall made. The mould consists of two end plates held firmly together by four distance rods. One end is a full plate. The other is cut out to the sectional dimensions of the block to be made. Hinged with short links to the four distance rods, are two side plates fitted with handles. The form is thus of box shape, without top or bottom, and with one end open. The open end fits over the part of the wall already made, and a bearing plate takes the weight of the form and prevents it cutting into the soft concrete. The box is then filled with concrete, which is allowed a short time to set and then the form is lifted by the two handles. This operation moves the side plates upwards and outwards, freeing the form from the block just made. The form is then advanced along this block and the process continued, a homogeneous wall resulting without bonding lines of any kind, except such as are liable to occur in all concrete work if for some reason or other operations are suspended for a considerable time. The forms are made suitable for various thicknesses of wall. The appliance has been recommended by the Ministry of Health (Housing Department). Double walls can be built with it, and, of course, separate blocks.

## INDUSTRIAL NOTES.

Mr. S. Sanderson, the secretary of the Lancashire Cardroom Workers' Approved Society, presided at a meeting held in Manchester last week, of the National Association of Trade Union Approved Societies, and in the course of his speech said that in his opinion the State had muddled everything it had touched. There was no real democratic control over State schemes; the outstanding feature of these was the enormous cost of administration. Out of every 1*l.* spent on the Poor Law 14*s.* went in administration; the unemployment dole cost 2*l.* in administration for every 1*l.* paid in unemployment; the white elephants called Labour Exchanges found employment largely for their own officials; the National Health Insurance cost 5*s.* to give a sick man 10*s.* The State was taking upon itself functions which it was never intended to discharge. State ownership should not be introduced where State control sufficed, and State control should not be applied any more than was necessary. Outside its sphere, the hand of the State was a dead hand. He had no objection to nationalisation, but it should first be proved that the change would be an improvement on the existing system.

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The Court of Inquiry, set up by the Ministry of Labour, to inquire into the application made by the National Transport Workers' Federation for a standard minimum wage of 16*s.* per day and various alterations in the conditions of employment of dock labourers, commenced its sittings last week in the Court of Criminal Appeal. Lord Shaw of Dunfermline presides over the Court of Inquiry. The inquiry in question is the first one on a large scale to be held under the Industrial Courts Act, 1919. The claim was submitted by the men to the employers last October; in November the men met the employers who, in December, suggested the Court of Inquiry. The sittings are continuing. According to the employers, the dockers' claim would involve an extra 10,000,000*l.* in wages.

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On Thursday evening, 5th inst., the Prime Minister received a deputation from the Committee of the Trades Union Congress and members of the Executive of the Miners' Federation, who put before him resolutions passed by the Congress on the nationalisation of mines, cost of living, unemployment and Russia. It is understood that the Prime Minister stated he could not say anything definite in regard to nationalisation; he had, however, not altered his views (against the Majority Report of the Coal Commission) on the subject, but the whole matter was one for discussion in Parliament and during this discussion his views might undergo modification. The other points referred to by the deputation would also be dealt with in Parliament.

On the following day, the Miners' Executive held a meeting, at the close of which the following statement was made:—

"In view of the answer given by the Prime Minister to the joint deputation from the Trades Congress and the Miners' Federation, which waited upon him last night, to the effect that the Government were not prepared to give legislative effect to the Majority Report of the Coal Commission as to the nationalisation of mines and minerals, that the miners now ask the Parliamentary Committee to convene the special adjourned Trades Union Congress at the earliest possible date in order to give effect to the resolution passed at the last special Congress, and also at the annual Congress at Glasgow."

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A circular, signed by Mr. Alfred W. Beuttell, factory manager of Messrs. John Brinsmead and Sons, Limited, pianoforte manufacturers, was issued last week to the men employed at the works. It stated that for each piano despatched per week there were now 26 employees as against 12 in 1918 and 6 immediately before the war, the factory wages alone per piano exceeding the selling price. The cost of polishing only was approximately equal to the pre-war prime cost of the completed piano, including materials. The directors had arrived at the decision to cease work, since they could not continue at the present heavy loss on production; they gave the employees one week's notice, terminating on the 11th inst. (Wednesday last). Other important piano manufacturers throughout the country controvert the above figures put forward by Messrs. Brinsmead.

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Mr. J. H. Thomas, M.P., speaking at Leyton last Saturday, and dealing with the protest raised against the proposed increase in the fares of the London underground railways, said he was satisfied that there was no money to meet the just demands of the men, and the only way to raise this money was by increasing the fares. He added that the National Union of Railwaymen would not be a party to giving cheap travelling facilities to the public at the expense of the sweated railwaymen. Mr. Thomas further stated that Labour's difficulty was not the strength of the other side, nor that their opponents were more clever than they, but was the damnable jealousy which existed within the movement. A meeting was held at the Memorial Hall, London, on the same day, to protest against the contemplated abolition of workmen's trains and workmen's fares, and against the proposed increase in the fares of the London underground railways and tramways, when Mr. C. W. Bowerman, M.P., the chairman, said they should not be unmindful of the difficulties of those who were responsible for running the railways. The problem was that wages and expenses were increasing, and if the railways did not pay, the only remedy was to nationalise them throughout. A statement of Mr. Bowerman's to the effect that the Executive of the National Union of Railwaymen had passed a resolution practically supporting the proposals that the fares should be increased was received with cries of "shame."

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Mr. R. Burton Chadwick, M.P., speaking last Saturday at a gathering of the Liverpool Shipping Staffs Association, said attention had been directed of late to the new move of the Labour Party in trying to get what was described as the "black-coated" brigade into the Labour movement. Brain workers were undoubtedly organising on trade union lines. They had got to recognise that fact. He, personally, was not opposed to trade unionism, but what the country was suffering from at the present time was badly-managed trade unionism. Up to quite recently, the Labour Party had never pretended to represent any other class than the manual workers and, as a matter of fact, that was the basis of their creed to-day; in spite of all the professions of loyal affection of Mr. Arthur Henderson and his friends, the Labour Party represented manual workers only. He, the speaker, hoped the "black-coated" workers would remain independent both of the employers and the Labour Party. He welcomed the new federation of brain workers, for he hoped that it would strengthen and improve trade union administration, which was one of the weakest points of the nation to-day, and which, if it continued in its present policy, would strangle the life out of the British Empire. There were those who did not like this organisation on the part of brain workers, but it had to be recognised and, if possible, directed into proper channels.

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We read in *The Yorkshire Post*, that the question of the adoption in the engineering industry throughout the country of the principle of payment by results has reached a critical phase. At a conference between the National Employers' Federation and the trade unions, held at York last week, the employers proposed the adoption of this principle, and at the same time offered concessions in regard to overtime, night shifts, apprentices and other matters. The trade union representatives replied that they had no authority to pledge their unions to the general adoption of payment by results, and thereupon the employers withdrew all their offers and the conference broke up without any arrangements being made for a resumption of negotiations. The 10 trade unions affected, the membership of which is about 600,000, have now decided to take a common ballot very soon on the question whether payment by results should be generally adopted. The craft unions are divided on the subject, and as the employers are strongly in favour of the principle, the position is regarded as grave.

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The Manchester Chamber of Commerce, in the course of its annual meeting, last Monday, passed a resolution asking for a reconsideration of the hours of labour in the cotton factories, with a view to increasing them. Mr. W. Sutcliffe, in moving the resolution, pointed out that the trade had to meet a demand showing an increase of 150 per cent. to 200 per cent., with a production which was 14 per cent. below that of pre-war days. Machinery could not be run faster to make up for the shortage, and it would be several years before new mills could be erected even if there were labour to run them. If the resolution were widely accepted by Chambers of Commerce, Government could call a conference of employers and operatives for agreeing to longer hours, there being a guarantee to return to present conditions in, probably, three or four years. The President said he felt certain that a resumption of pre-war hours of labour would be quite impracticable. The men would not agree to work in the early hours of the morning again, and he would not ask them to do it. He suggested that the resolution should be altered. Mr. Sutcliffe accepted the President's suggestion, and the resolution was finally carried in the following form:—"That the members of the Manchester Chamber of Commerce recommend the Government to make a strong appeal to the various employers' federations and trade unions for a temporary extension of the present working hours in order to meet the existing deficiency in production. By this means the amount available for export would be materially increased, and would assist towards checking the depreciation in the value of British currency abroad, and so prevent a further increase in the cost of imported foodstuffs and other essential commodities, which must take place if the foreign exchange continues to move unfavourably to this country."

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We earnestly recommend to our readers, both workmen and employers, a pamphlet entitled "Stability as the Basis of Industrial Peace," reprinted from *Ways and Means*, by Mr. E. W. Petter, published by the Industrial League and Council, 82, Victoria-street, S.W. 1. In this, the author gives the reasons for the present unsatisfactory situation in the United Kingdom, and states as the remedy the following: The stabilisation for a year, until March, 1921, of wages and hours of working in all trades at the present rates; during this time, it would be agreed that workers would not ask for increases in wages and employers would not ask for reductions; further, it would be agreed by all parties that unrestricted production shall be the order of the day, the whole supplemented by a satisfactory and comprehensive scheme of National Unemployment Insurance. The effect of this, on employers, would be that they could give firm quotations on all inquiries and accept orders at fixed prices for all goods that could be supplied during the stabilised period. There were plenty of orders obtainable and there was no danger that economic conditions would operate against us during the period suggested. The workers, on their part, would know that during the same period the benefit of reduced cost of living brought about by increased production would be enjoyed by them, and they would be safeguarded against the consequences of unemployment. They would, in fact, enter into a national profit-sharing scheme. The author ventures to predict that in three months the cost of living would be down by 15 per cent., and that this reduction would be progressive during the whole period of stabilisation of wages and unrestricted output. In fact, such an increase would be brought about in real wages—as distinct from mere counter value—beyond the most sanguine dream of the workers themselves.

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Ex-British Westinghouse Association.—The second annual dinner of the above association was held in the Holborn Restaurant on January 23, when some 150 members assembled. The association now has a membership of about 200, and as far as is known there are in all about 400 persons eligible for membership. It is hoped that the extra publicity obtained as a result of the dinner may lead to an increase in membership. All particulars may be obtained from the Hon. Secretary, Mr. L. S. Richardson, 14, Sydney-road, Richmond, Surrey. The objects of the association are to provide means by which ex-members of the British Westinghouse Electric and Manufacturing Company may keep in touch with each other by meeting and dining together annually. The subscription to the association is only 2*s.* 6*d.* a year, and as this covers the receipt of a booklet containing a list of names and addresses of members, it forms a very cheap means of keeping in touch with the movements of old friends. A very enjoyable evening was spent on the 23rd ult., and the association had the pleasure of listening to a speech from Lieutenant-Colonel Montague Cradock, C.B., C.M.G., who attended as a guest.

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Coal Production in Canada.—Statistics as to the coal production in other countries are of especial interest at the present time in enabling us to compare the conditions existing in the coal industries of these countries with those prevailing in the United Kingdom. According to a recent publication of the Canadian Department of Mines the coal production of Canada in 1918 amounted to 14,977,926 tons, and, as 25,419 men are employed in the industry, the output per man was about 590 tons per annum. The total sum paid in wages during the year was 32,899,501 dols., so that the labour cost comes out at about 2·2 dols. per ton, and, since the average selling price per ton was 3·68 dols., the amount available for other working costs and profits was 1·48 dols. per ton. In the previous year the output was slightly less, being 14,046,759 tons, and the number of men employed was only 24,596, so that the annual output per man employed works out at 571 tons. The wages paid during the year were considerably less, viz., 25,963,520 dols., or 1·85 dols. per ton, but, as the average selling price was 3·08 dols. per ton, the other charges and profits were not very different, being 1·43 dols. per ton instead of 1·48 dols. per ton. It is interesting to note that the greater part of the 1918 production came from the provinces of Nova Scotia and Alberta, each of which produced nearly 40 per cent. of the total. Most of the remainder came from British Columbia, though small quantities were produced in Saskatchewan, New Brunswick and the Yukon Territory. It may also be mentioned that, of the total production for 1918, 78 per cent. was bituminous, 21 per cent. lignite and 1 per cent. anthracite. Canada imported 21,678,587 tons of coal during the year and exported 1,817,195 tons, so that her total consumption would be 34,839,318 tons on the assumption that the quantity in stock was the same at the end of the year as at the beginning.

# RECENT ADVANCES IN UTILISATION OF WATER POWER.*

By ERIC M. BERGSTROM, of London, Associate Member.

(*Concluded from page* 197.)

## SPEED REGULATION.

The development of the design and construction of governors has naturally been closely bound up with the general advances in the design of Francis turbines. In fact, it may be stated without exaggeration that the progress in the application of water turbines is to a great extent due to the satisfactory solution of the governor problem as the provision of a quick-acting and reliable speed-controlling device forms one of the most important features of hydro-electric development.

The old type of mechanical governor, of which Fig. 26 shows a well-known example, proved totally inadequate for the needs of efficient speed control in connection with hydraulically-driven generators. As a consequence, the hydraulic type of governor was evolved which in the first place was actuated by the water pressure, but later, however, was substituted by oil pressure in order to eliminate several bad features of the water-pressure governor, that is, sticking due to gritty water, and liability to corrosion of the various mechanical parts. The automatic oil-pressure type of governor has been steadily improved and has now reached a high state of perfection, possessing all the qualities required by modern practice for effective and reliable speed control.

Although a large number of oil-pressure governors have been introduced, all embodying different mechanical construction, the same principle of operation has been retained as is shown diagrammatically in Fig. 27 where A represents oil pump, B oil-pressure receiver, C servo-motor or hydraulic cylinder, D distributing valve, E centrifugal pendulum, and F relay motion or anti-racing mechanism. The pump as well as the pendulum is driven from the turbine shaft, and if the turbine is running at its normal speed the pendulum is so adjusted that the sleeve L as well as the distributing valve O would be in the central positions as indicated on the diagram. If, however, the load on the turbine should decrease and consequently the speed increase, the sleeve L would rise, in turn lifting the valve D through the lever O with Z as a fulcrum, causing the oil pressure from the pressure receiver to be admitted on the left side of the servo-motor piston and moving the guide vanes in the closing direction through the governor shaft R. At the moment the shaft R starts to turn, however, the lever F will move, in this instance downwards, and lower the connecting rod J, consequently bringing the distributing valve back to its central position through the lever O with the point L as a temporary fulcrum. The pressure supply to the servo-motor is thus cut off and prevents the gates on the turbines from closing further than necessary to establish equilibrium between the load and corresponding output of the turbine. By means of the small hand wheel K on the relay motion, the connecting rod J can be either shortened or lengthened, thus enabling the speed of the turbine to be slightly decreased or increased during running, independent of the load.

In this arrangement of governor each position of the guide vanes corresponds to a certain position of the governor sleeve, the difference in speed between "full" and "no load" depending on the degree of irregularity of the governor, usually 3 per cent. to 5 per cent. Under certain conditions it may, however, be necessary to increase the degree of irregularity even up to 10 per cent. to 12 per cent. to obtain stable governing conditions, and as this speed variation could not be permitted in connection with alternators coupled in parallel, such governors are now provided with a device to obtain a constant speed at all loads. This arrangement is shown in diagram Fig. 27.

The principle of this device is that instead of the relay motion gear forming a rigid connection between the pendulum lever and governor shaft as before described, the connecting rod J is fitted with an oil dashpot with springs, which, after each regular movement brings the pendulum sleeve back to its central position, thus maintaining constant speed corresponding to the speed for which the governor has been adjusted. The dashpot M consists of a cylinder with a piston and an intercommunicating pipe allowing the oil in the cylinder to flow from one side to the other, the rate of flow being controlled by the adjusting screw N. When a load change occurs in either direction the relay motion will come into operation as before described, but as the oil in the dashpot cannot pass quickly enough from one side of the piston to the other, the connection between the pendulum lever and governor shafts can be considered as rigid and the dashpot cylinder will follow the movement of the piston and bring the distributing valve back to its central position. The springs P attached to the cylinder, each of which is compressed or under tension according to the direction of the movement of the piston will, however, bring the cylinder back, and thereby the point Z to its previous position, the piston remaining stationary. With the movement of the point Z the distributing valve will again cause the governor either to open or close, thus adjusting the speed until L takes up its central position corresponding to constant speed on the turbine.

Fig. 28, above, shows an outside view of a type of oil-pressure governor built on the principle described. It will be observed that the whole governor is self-contained on its own bedplate, which at the same time serves as an oil supply tank, the governor shaft being connected to the guide apparatus on the turbine by means of levers and connecting rods. This type of governor is now made in standard series in varying sizes and power ranging from 350 ft.-lb. to 40,000 ft.-lb. capacity. In addition to the hand wheel on the relay motion gear, by means of which the turbine gates can be controlled by hand at any time or used to shut down, a mechanical hand-operating gear is provided for the same purpose, the change-over from automatic to mechanical control being possible during running. The distributing valve on which the quickness and smoothness of the governor action, and the accuracy with which it responds to the speed variation to a great extent depends, generally consists of a relay valve controlling the ports connecting

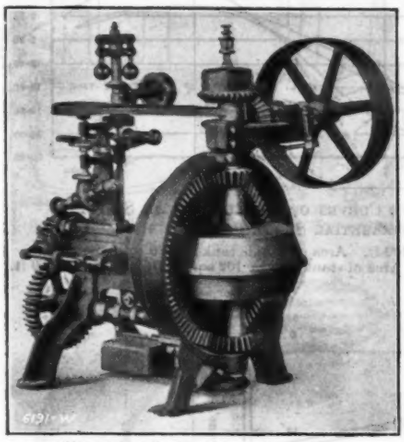

FIG. 26. MECHANICAL GOVERNOR.

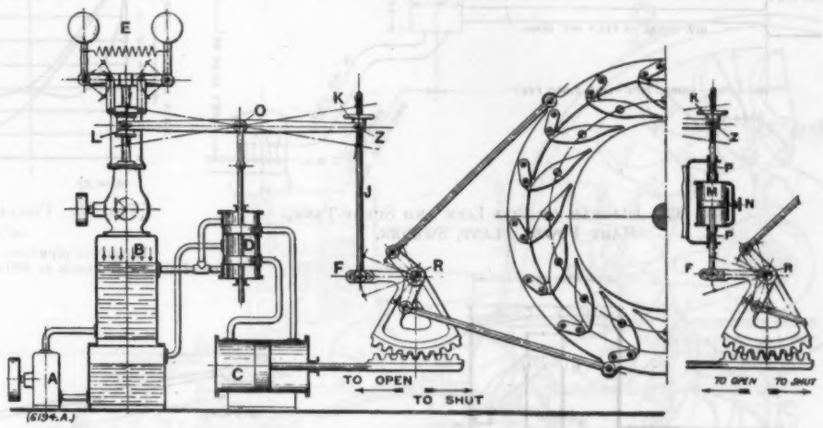


FIG. 27. DIAGRAM SHOWING THE PRINCIPLE OF AN OIL-PRESSURE GOVERNOR.

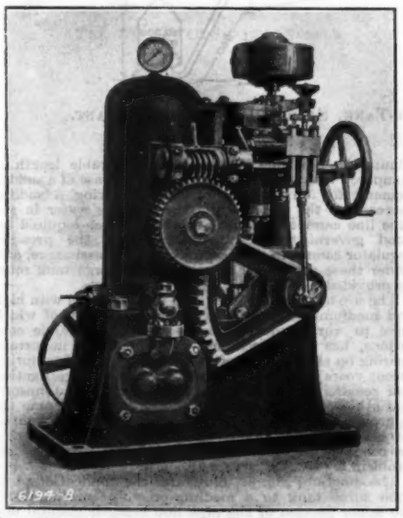

FIG. 28. AUTOMATIC OIL-PRESSURE GOVERNOR. (SIZES VARYING FROM 350 TO 40,000 FT.-LB. CAPACITY.)

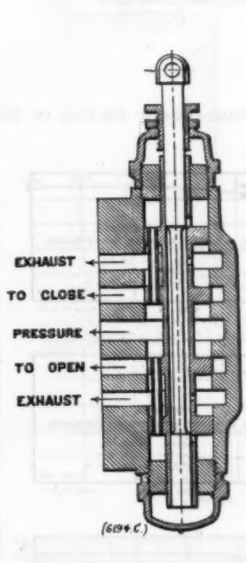


FIG. 29. DISTRIBUTING VALVE FOR OIL-PRESSURE GOVERNOR.

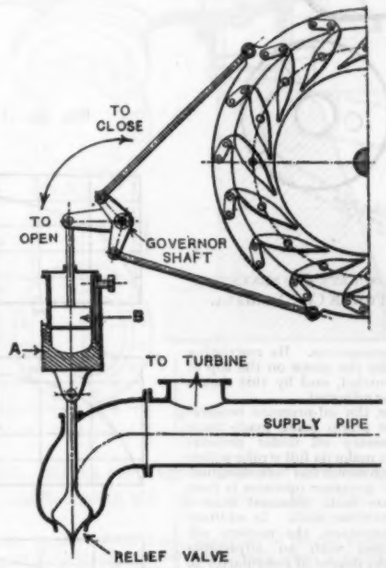


FIG. 30. GOVERNOR-OPERATED RELIEF VALVE AS APPLIED TO TURBINE.

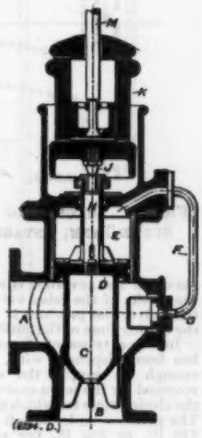

FIG. 31. RELAY VALVE OPERATED BY GOVERNOR.

* Paper read before the Institution of Mechanical Engineers, on Friday, January 23, 1920.

the pressure receiver with the servo-motor which in turn is controlled by a pilot valve actuated by the pendulum.

The distributing valve in Fig. 29 shows a typical design, the relay-valve being entirely balanced by oil pressure in its central position. The pilot valve, however, controls the oil pressure on both sides of the relay valve, and when lifted or lowered by the governor pendulum, relieves the oil pressure either at the top or bottom of the relay valve, thus permitting the pressure oil to enter the servo-motor. As the relay valve is floating in oil, the friction is infinitesimal, and as the valve only overlaps less than 1 mm. at the ports, the "dead time" is brought to a minimum and consequently the action of the governor is instantaneous. By restricting the stroke of the relay valve by the screw on the top of the valve, the pressure is throttled, and by this means the closing time of the governor adjusted.

In some types of governor the oil-pressure receiver has been dispensed with, the pump being made large enough to supply the necessary oil under pressure required for the servo-motor to make its full stroke within the closing time for which the governor has been designed. The pressure under which the governor operates is from 150 lb. to 200 lb. per square inch, obtained from a rotary pump driven from the turbine shaft. In addition to the constant-speed compensation, the modern oil-pressure governor is equipped with an adjustable equalising device permitting the degree of irregularity to be adjusted within certain limits, which enables the turbine to run in parallel with alternators driven by steam engines, the governor being adjusted for the same degree of irregularity as the governor head on the engine regulator. The governor can also be arranged for distant speed control from the switchboard, which is of great assistance in the operation of parallel driven alternators.

For large turbine units where a large-capacity governor is required, the servo-motor is built together with the turbine, and in the case of several units, are all supplied from a central oil-supply system. In the case of enclosed turbines supplied through pipe lines, the closing time of the governor and guide vanes respectively must be adjusted correspondingly longer than in the case of open-type turbines in order to avoid dangerous pressure rises in the pipe line, owing to the change of momentum of the flowing mass of water, in addition to providing a heavy flywheel to keep the speed variation within permissible limits. This arrangement is only possible where the pipe line is comparatively short and cannot be adopted for high-pressure turbines where the hydraulic conditions imposed by high head and long pipe lines render the governing problem far more difficult. In such cases the governor is operated in conjunction with a pressure regulator or relief valve, in such a manner that when the governor closes the guide vanes of the turbine the relief valve opens, discharging the water into the tailrace, so that the same amount of water is flowing through the pipe line, thus avoiding any change in the momentum, and consequently no pressure rise can occur.

The arrangement of such a pressure regulator is shown diagrammatically in Fig. 30. Simultaneously as the governor closes the guide vanes, the piston B in the oil dashpot cylinder A is lifted. The valve is connected to the cylinder which contains a passage allowing the oil to pass from one side of the piston to the other, the rate of flow being adjusted by a small needle valve. When the piston B is lifted the cylinder will follow, and consequently the valve will open at the same rate as the governor closes the turbine. The cylinder is, however, loaded with a heavy weight which exerts a pressure on the oil, which will slowly flow to the lower side of the piston and gradually allow the valve to be closed. By means of the needle valve the rate of closing is regulated sufficiently slowly to prevent any dangerous shocks in the pipe line.

In the type of pressure regulator just described, it will be observed that the governor furnishes the necessary power to operate the valve. This type of valve could not be used with advantage in many plants, as a very large-capacity governor would be required to operate the valve. The modern type of pressure regulator for Francis turbines has therefore been designed in such a manner that the governor only operates a small relay valve, the water pressure in the pipe line being utilised to operate the valve and thus obviate the additional power being imposed on the governor. A section of a valve of this type is shown in Fig. 31, the governor actuating the distributing valve, admitting or releasing the water pressure behind the piston operating the valve. At the same time, the dashpot device as in the previous illustration, prevents a rapid closing, ensuring a gradual change of the velocities of the water in the pipe line and obviates any undue pressure increase. This type of pressure regulator is only suitable for high heads and a comparatively small quantity of water, whereas for medium heads and large volumes of water, its use, for practical reasons, is prohibitive,

A further point which must be subject to particular consideration is the fact that in many medium-pressure plants the pipe line is often of considerable length as compared with the total head, so that in case of a sudden demand for an increase of flow following a sudden increase of the load on the turbine, the water in the pipe line cannot accelerate at such rate as required by good governing. It is apparent that the pressure regulator cannot in this respect be of any assistance, and under these conditions a standpipe or surge tank must be provided.

The use of long pipe lines both in connection with high and medium-pressure Francis turbines, many of which have to work under the most adverse hydraulic conditions, has introduced new factors having important bearing on the problem of speed control, and has during recent years been the subject of theoretical investigation and research, notably by Allievi, Prazil and Johnson* and others, with the result that the laws governing the hydraulic conditions in relation to the speed control have now been definitely formulated and consequently have enabled a practical solution of this very intricate problem.

The diagram, Fig. 32, illustrates the application of an open surge tank to a medium-pressure turbine plant, the upper portion of the pipe line being horizontal and the surge tank situated near the power-house. In the event of a sudden throwing off of the load on the turbine, the water would rise in the tank and absorb the energy given out by the flowing water column when changing its momentum during the retardation of the flow and corresponding to the new load conditions. On the other hand, in the event of a sudden demand for more power, the stored water in the surge tank would instantaneously supply the additional quantity of water required until the water column in the upper portion of the pipe line has had time to accelerate, and consequently the level in the tank would be lowered. The area of the tank must be so dimensioned that the amplitudes of the water waves or oscillations are as small as possible and steadily diminish until the quiescent water level is reached, in order not to influence adversely the conditions for stable governing.

An important improvement in the design of surge tanks is to be found in the so-called differential surge tank recently introduced in America.† The object, with this new design, was to obviate the disadvantages of the considerable oscillations obtained in the simple tank as often the cost of a larger diameter tank to reduce the oscillation has proved prohibitive. The differential

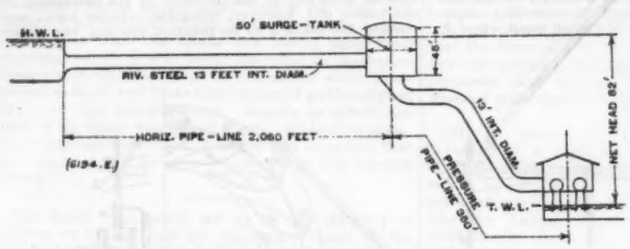


FIG. 32. DIAGRAM OF PIPE-LINE AND SURGE-TANK, HABY POWER PLANT, SWEDEN.

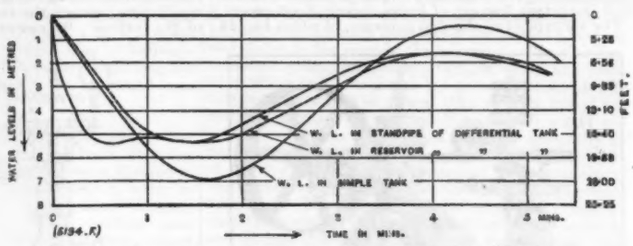


FIG. 33. COMPARATIVE CURVES OF OSCILLATIONS IN SIMPLE AND DIFFERENTIAL SURGE-TANKS.

Length of pipe line = 11,300 ft. Area of simple tank = 680 sq. ft.
Area of differential tank = 580 sq. ft. Area of standpipe = 102 sq. ft. Gross head = 250 ft.

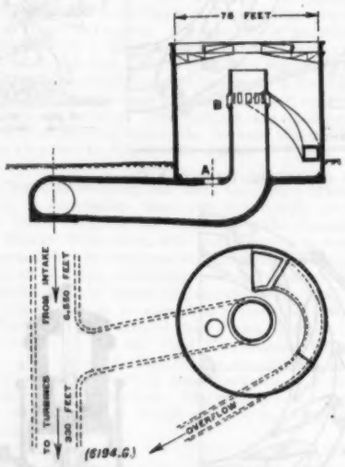


FIG. 34. DIAGRAM OF CONCRETE DIFFERENTIAL SURGE-TANK, ONTARIO POWER CO., NIAGARA.

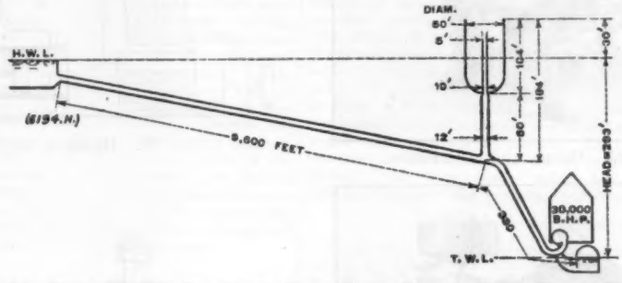


FIG. 35. DIAGRAMMATIC SECTION OF SURGE-TANK, SALMON RIVER POWER PLANT.

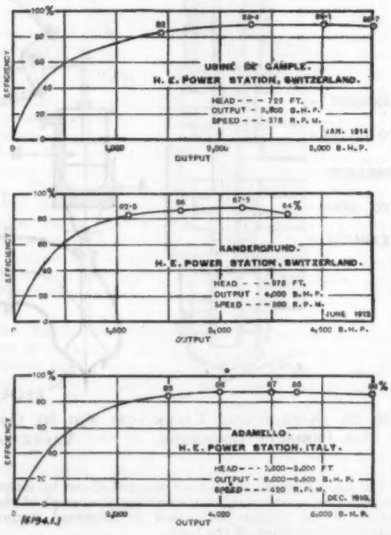


FIG. 36. PELTON WHEELS. EFFICIENCY CURVES.

*L. Allievi: Annali della Societa degli Ingeneri ed Architetti; Rome, 1903. Dr. F. Prazil: "Schweiz Bauzeitung," Zurich, vol. lii, 1908. R. D. Johnson: American Soc. Mech. Eng., 1908.

†R. D. Johnson. "The Surge Tank." Trans. American Soc. Civil Eng., vol. lxxviii and lxxix, 1915.

surge tank consists of a standpipe of approximately the same diameter as the pipe line and communicating with the reservoir through a comparatively small accurately-dimensioned opening. When for instance the load is suddenly increased, the water in the standpipe will fall rapidly owing to the throttling effect of the opening of the reservoir, and consequently the water in the pipe line will accelerate at a more rapid rate than in the case of a simple surge tank where the water column in the upper pipe line accelerates only at the same rate as the water level in the reservoir falls. By thus increasing the acceleration from the very beginning of the regulation period, less amount of storage water is necessary, which permits a smaller reservoir and consequently less cost than in the case of a simple tank. To illustrate the comparative effect on the oscillations obtained in the two types of surge tanks, Fig. 33 shows the variation in water levels in the simple and differential surge tank respectively during a sudden increase in load, which clearly indicates that the oscillation is of less magnitude in the latter type of tank.

F.g. 34 shows a differential tank constructed in reinforced concrete in connection with the Ontario Power Company's Hydro-Electric plant at Niagara.* A represents the opening between the standpipe and reservoir through which the water flows during normal load variation, but in case of an exceptionally heavy load being thrown off, the water would also escape over the top and through the opening B. The internal diameter of this tank is 75 ft., the net working head on the turbine being only 18 ft. 6 in.

The arrangement of a differential tank as applied to a high-pressure plant is shown in Fig. 35, which is of particular interest on account of its very large dimensions and height. In this case it is obvious that the construction of a simple tank for the existing conditions would be impracticable on account of its great cost. The stand-pipe has a diameter of 12 ft. with a height of 80 ft. connected to the reservoir having a diameter of 50 ft. and a height of 105 ft., the highest point of the roof being 205 ft. above ground level, and the total capacity of the reservoir being 1,400,000 gallons of water, and is one of the highest surge tanks yet constructed.

The problem of satisfactory speed control is necessarily of a theoretical character, but without touching this side of the question the author has endeavoured to bring out the outstanding fact that the advancement in respect of regulation has played an important role in the general development of hydro-electric plants, and without excluding the possibilities of further improvements it can be said that the speed regulation of Francis turbines has reached a high standard of perfection, in fact is second to none compared with any other prime mover.

Long pipe lines, which from the point of view of speed regulation proved to be an obstacle to many power developments, need not now be avoided for that reason, although in addition to the purely technical side the economic aspect requires careful consideration in cases where the topographical conditions necessitate extremely long pipes or conduits. It is imperative, however, that the arrangement of such a plant should be left in the hands of the expert hydraulic engineer, as in the past many plants have proved to be failures for want of consideration of the many complex problems arising in connection with speed regulation under disadvantageous hydraulic conditions.

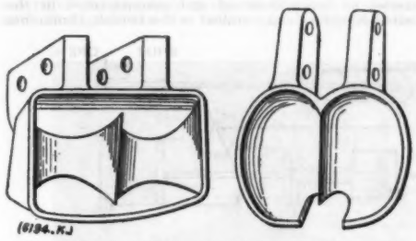


FIG. 37. BUCKETS FOR IMPULSE TURBINES.

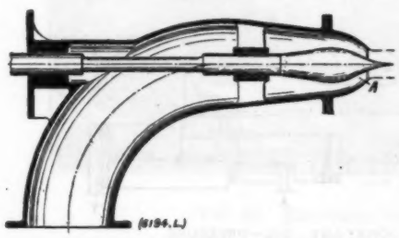


FIG. 38. PEAR-SHAPED NOZZLE.

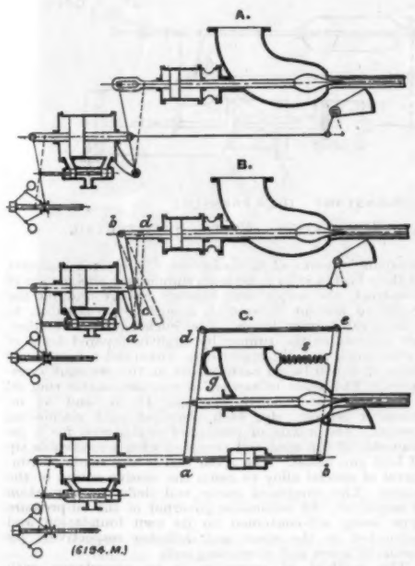


FIG. 39. REGULATION OF PELTON WHEELS.

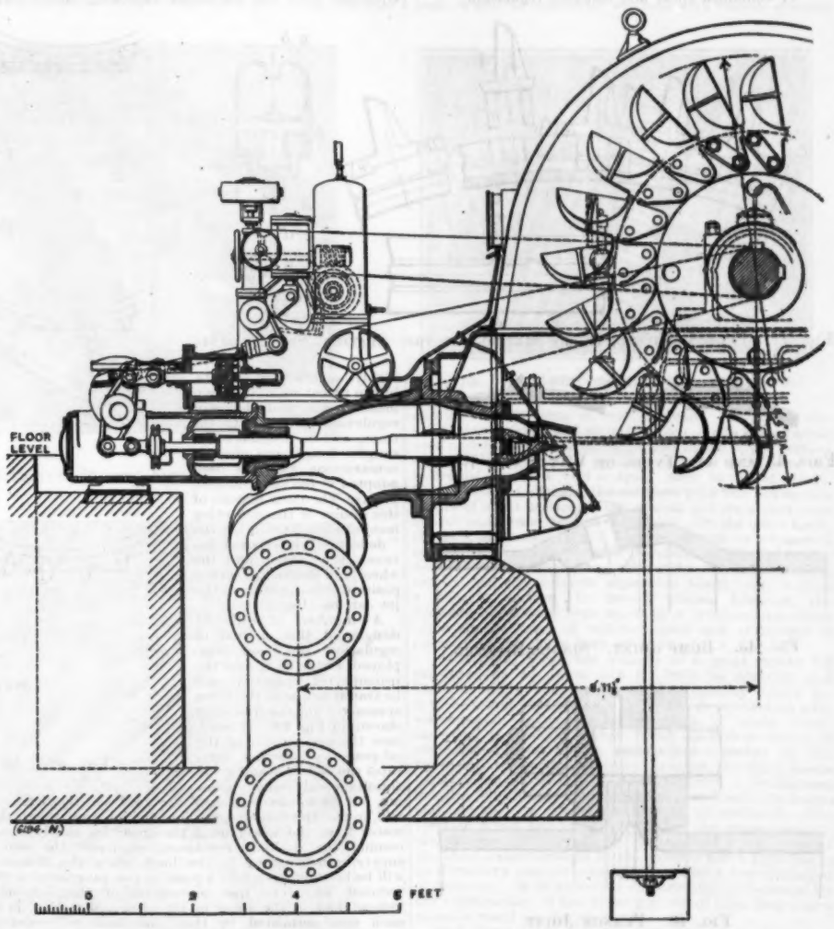


FIG. 40. SINGLE-JET PELTON WHEEL, KINLOCHLEVEN.
Output 3,300 B.H.P. Head 875 ft. 300 R.P.M.

PELTON WHEELS.

The second category comprises the high-pressure impulse turbine more familiarly known as the Pelton wheel, named after its American inventor, and is of the purely impulse type; the water issuing from a nozzle at the full velocity corresponding to the net head and impinging on a set of buckets bolted on to the rim of the wheel centre. The Pelton wheel is used under heads varying from about 500 ft. to 2,000 ft., although for small powers it can be used under medium heads of down to 100 ft., and on the other hand has been employed under a maximum of 5,400 ft. in one stage. In comparison with the great advancement made during recent years in the design and construction of reaction turbines, the improvements in the impulse type of turbine have perhaps not had the same far-reaching effect on account of its design being of a comparatively simpler nature, but great strides have been made in also bringing this type of turbine on the same high level demanded by the present-day practice.

The chief characteristic of the impulse wheel is the long range of load during which the efficiency is nearly constant, as can be seen from the efficiency curves reproduced from official tests, Fig. 36. In each case the efficiency at half load is over 85 per cent., and only fails below 80 per cent. when the load is less than 30 per cent. of the normal. To obtain the maximum efficiency the ratio between the pitch diameter of the wheel and diameter of the jet should not be less than 12, although in certain cases a ratio of 10 : 1 may be used when a higher speed is secured at the expense of efficiency.

The maximum specific speed obtained for a single runner and jet is therefore limited to 5 (23), corresponding to a ratio between runner and jet of approximately 11 The maximum speed, for instance, obtained with a single jet for, say, an output of 3,000 brake horse-power under 900 ft. would be $5 = \frac{N\sqrt{3,000}}{900^{\frac{5}{4}}}$. Thus N = 450 r.p.m.

To obtain a higher speed under a given head than that corresponding to the maximum specific speed, it is essential to divide the power over two or more nozzles or wheels. On account of the discharge from the buckets interfering with lower jets, it is now seldom that more than two nozzles are provided for each wheel, and where more nozzles are required the power is divided over two runners each with double nozzles. Double nozzles were also provided where the diameter of a single jet would have exceeded 5 in. to 6 in., but in recent years single jets of 8 in. diameter have been used with advantage. The outstanding feature in the improvement has been in respect of the shape of buckets and nozzle and the design of the regulating device.

The original Pelton buckets were rectangular in section, Fig. 37, but have been superseded by the elliptically-shaped bucket which has now been universally adopted by all makers, as the absence of sharp corners and abrupt changes of direction of the stream favours the reduction of the hydraulic losses. The same tendency

* R. D. Johnson, "Concrete Surge Tanks." *Engineering Record.* New York, March, 1915.

to adopt a uniform design is also noticeable in respect of the nozzle where the various designs of rectangular nozzle with movable lip have been discarded in favour of the circular nozzle with concentric pear-shaped spear or interceptor movable in axial direction for regulating the quantity of water, Fig. 38, which now without exception is employed in modern Pelton wheel design. The most important improvement, however, is in respect of the system of regulation which, as in the case of the Francis turbine, had to be adapted for the new conditions of electrical transmission and at the same time conform to the increased demand for accurate and reliable automatic governing.

Three distinct systems of automatic governing are now employed, namely :—

A. By-pass valve regulation.
B. Regulation with deflecting nozzle.
C. Combined spear and deflector regulation.

consists of a needle valve directly operated by the governor.

For Pelton wheels for considerable outputs and comparatively low heads, employing two runners with two or more jets, and consequently a large quantity of water, the by-pass valve is generally operated indirectly by the governor in the same manner as the relief valve in connection with Francis turbines. Although the by-pass regulation has been employed in a large number of plants, the inherent defect of liability to stick and excessive wear, together with the difficulty of ensuring synchronising action, called for further improvements in design, resulting in the introduction of the deflecting nozzle; in this construction the complete nozzle is pivoted on its perpendicular axis and deflects the whole or part of the jet from the wheel and discharge direct into the tail-race. A number of plants have been equipped with this particular regulating device, with governor would operate directly on the needle, the deflector being simultaneously moved forward through the lever *d e* to maintain its tangential position corresponding to the reduced jet. This latter design differs from the two foregoing in respect of operation when small and gradual load changes occur, inasmuch as in that case the governor would operate the needle directly the deflector remains inactive, with which system, it is claimed, more steady speed regulation for small load changes is obtained.

An illustration of the mechanical design and arrangement of modern Pelton wheels is afforded by the following description of a few representative installations. Fig. 40, page 229, shows a single-jet Pelton wheel designed for an output of 3,300 brake horse power under a net head of 875 ft. at 300 r.p.m., which plant may be of special interest as being designed and manufactured in the United Kingdom and installed at the British Aluminium

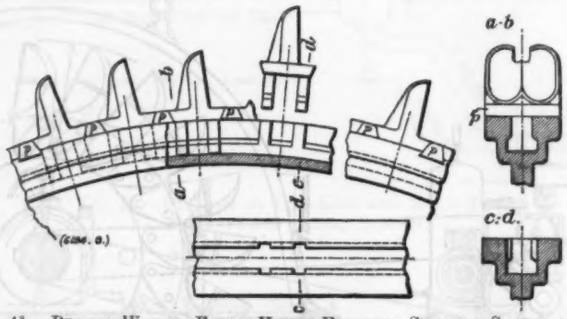


FIG. 41. PELTON WHEEL, FULLY HYDRO-ELECTRIC STATION, SWITZERLAND.

FIGS. 43 AND 44. TYPES OF WATER GAS WELDS.

FIG. 45. BUMP JOINT. SINGLE-RIVETED.

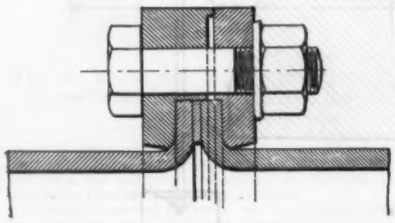

FIG. 46. FLANGE JOINT.

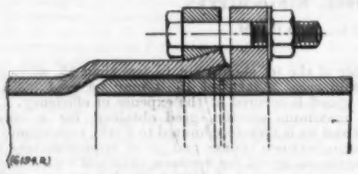

FIG. 47. HIGH-PRESSURE "MUFF" JOINT.

The object aimed at in each of these methods of automatic control is to obtain an instantaneous regulation of the quantity of water in response to any load changes, at the same time ensuring a slow and gradual retardation of the flow in the pipe line to obviate any dangerous increase in pressure.

The by-pass regulation is the oldest type used in combination with the automatic governing of Pelton wheels, and as indicated by its name, consists of a by-pass valve, the principle of which has already been referred to in connection with high-pressure Francis turbines. The regulating shaft on the oil-pressure governor of the standard type acts direct on the movable spear of the nozzle, instantaneously establishing equilibrium between the quantity of water reaching the wheel and the load on the turbine. At the same time, in case of a sudden throwing-off of the load, the by-pass valve will open at the same rate as the spear closes, and then close slowly by the pressure of a spring against the dashpot. As the quantity of water is usually small, the by-pass valve

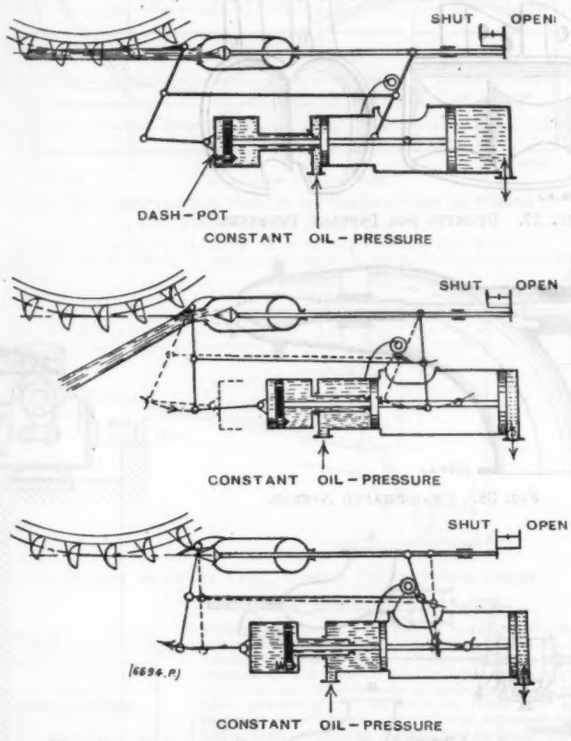


FIG. 42. AUTOMATIC REGULATION. FULLY, SWITZERLAND.

highly satisfactory results, but in recent years the combined spear and deflector regulation has come to the front, and on account of its simpler design and cheaper construction has now been adopted in the most modern plants. The main feature of this design is the deflecting hood or shoe known as the "deflector" interposed between the nozzle and the wheel and pivoted in such a position that direction of the jet can be altered.

A number of different designs of this method of regulation are now employed, but in each case the principle of operation can be traced to one of the three systems diagrammatically shown in Fig. 39. In each case the servo-motor of the oil-pressure governor operates the deflector and spear simultaneously when opening, but by sudden closing of the governor the deflector will, in the first instance, cut into the jet and divert the water from the wheel until the spear by slowly overcoming the dashpot resistance, regulates the water supply corresponding to the load, when the deflector will be brought back into a position just tangential to the reduced jet. The free movement of the deflector, independent of the spear in the closing direction, is in each case permitted by the "lost motion" existing in the mechanical connection between the deflector and spear.

In A the spear rod is provided with a slot in which the pin of the lever connecting to the governor shaft can slide. The opening and closing position of the deflector is shown, the latter in dotted lines, and by the pressure of the spring against the retarding action of the oil dashpot the spear will slowly move forward until the slot has regained contact with the sliding pin.

In B the operation is identical with A, although the lost motion between the deflector and spear is obtained through a displacement of the lever system relative to the fixed point *a*. In the closing direction the lever *b c* will follow the deflector movement with *b* as a fulcrum and take up the position as indicated in dotted lines on the diagram. The spring is now free to expand and exerts the necessary pressure to close the spear until the lever *b c* has regained contact with *a*, corresponding to the position *b c* in the diagram. In each of these two methods described it will be observed that, firstly, the governor, irrespective of whether the load is thrown off gradually or instantaneously, always operates directly on the deflector, the spear meanwhile remaining stationary; secondly, that the governor brings the deflector out of the jet after each governing operation.

In diagram C a dashpot has been interposed between the governor servo-motor and deflector lever. By sudden discharge of load points *a* and *b* practically will move the same distance, consequently the deflector will cut into the jet and at the same time lever *a d* is moved away from the stop *g*. The spring, however, is strong enough to overcome the dashpot resistance and slowly brings the spear into position, at the same time lifting the deflector into a position tangential to the new jet. If, on the other hand, the load is only gradually discharged, the point *b* would remain stationary and the

Company's works at Kinlochleven. The pitch diameter of the wheel is 82 in., and both runner and buckets are of cast-steel, the latter sand-blasted and ground on the inside to present as smooth a surface as possible, to reduce the friction losses. The buckets, 20 in number, are secured to the runner by slightly tapered bolts of nickel steel, and dimensioned to withstand a centrifugal force of 90,000 lb. on each bucket at 100 per cent. overspeed. The shaft is carried in two automatic ring oil lubricated water-cooled bearings, 11 in. and 8½ in. diameter respectively, each provided with circulating pumps. The nozzle of cast steel is designed for a jet diameter of 148 mm. and provided with a renewable tip of best gun-metal. The spear end is also made of gun-metal of special alloy to resist the erosive action of the water. The combined spear and deflector regulation is employed, the automatic governor of the oil-pressure type being self-contained on its own foundation and connected to the spear and deflector respectively by means of levers and connecting rods.

The method of operation is in accordance with diagram A, Fig. 39, although for the sake of better mechanical arrangement the dashpot is indirectly connected to the spear by means of a system of levers.

The governor has been designed for a closing time of 1 second corresponding to a maximum temporary speed variation of approximately 8 per cent. when the total load of 3,300 brake horse-power is instantaneously thrown off. By reason of the arrangement of the existing distributing pipe lines, the Pelton wheel is provided with double inlet, each fitted with a 21-in. hand-operated sluice valve, which enables, if required, the unit to be supplied through any particular supply pipe. The shaft is provided with a solid flange coupling connecting to the 2,000 kw. direct-current generator.

*Fully Hydro-Electric Station, Switzerland.**—By reason of the extremely high fall under which this plant operates, it is of singular interest and particularly serves as an illustration of the latest achievements in Pelton wheel design. The output is 3,000 brake horse-power per unit at 500 r.p.m. under a working head of 5,435 ft., being

* R. Neeser. "Les machines hydrauliques à l'Exposition de Bern." *Bulletin Technique de la Suisse-Romande*, 1916.

the maximum head which any turbine has been designed to utilise in one stage. The pitch diameter of the wheel is 11 ft. 7 in., and that of the jet 34 mm., corresponding to a ratio of approximately 105. The velocity of the jet is approximately 35,000, and the peripheral velocity of the wheel disc 18,200 ft. per minute. Under these circumstances the most careful consideration had to be given to the design of the runner and the method to be adopted for fixing the buckets. The runner is a steel forging and designed as a disc of uniform strength. The buckets are also of steel forged on blocks, but on account of the extremely high peripheral velocity the method of fixing by bolts could not be adopted, and quite a novel method was resorted to. The runner is provided with a wedge-shaped slot, and each bucket has two lugs of corresponding section, Fig. 41, opposite, and round the periphery of the rim openings have been made through which the buckets can be inserted, the required spacing being obtained by means of distance-pieces of triangular section. Of these distance-pieces nine were of special design and spaced evenly round the periphery, after which the disc was heated and the buckets and the intermediate distance-pieces inserted cold. To secure the required pressure fit between the buckets and the distance-pieces a strip of steel plate, the thickness of which had been carefully determined beforehand, was inserted in the nine sections, and which, after the disc had been allowed to cool, exerted the pressure necessary for a tight fit.

The automatic speed regulation is carried out by means of the combined spear and deflector arrangement (type C, Fig. 39), and to afford a clearer conception of the various phases of regulation, Fig. 42 shows the relative position of the deflector and spear respectively during the closing operation. The spear is in this instance operated by means of an auxiliary oil-pressure servo-motor, which, however, has been purposely omitted in the diagram, for the sake of a clearer view of the essential parts.

Position I represents the full open position with the deflector tangential to the maximum jet.

Position II represents the moment immediately the load has been discharged, the deflector diverting the jet, but with the spear still stationary in its open position, the dashpot having moved from left to right, together with the servo-motor piston.

Position III represents the full closed position, the dashpot slowly moving from right to left and permitting the gradual closing of the spear at the same time as the deflector is lifted until it takes up a position tangential to the centre line of the jet.

In each of the foregoing plants the wheel has been carried in two bearings and mounted on a separate bedplate. The arrangement of the "overhung" wheel direct-mounted on the generator shaft has been greatly in vogue in America, and has lately also been adopted in Europe, but to a much smaller extent. This arrangement is characterised by its cheapness and compactness and consequently a great saving of floor space is secured. For double turbines, one wheel is mounted in a similar manner at each end of the generator shaft, which arrangement was adopted at the Southern California Edison Company's power plant at Kern River, California,* with a total output of 10,000 brake horse power per unit and a jet diameter of 7¼ in. The vertical arrangement of Pelton wheels is more seldom adopted, but possesses the advantage of permitting the use of four or even more nozzles with a single wheel. A detailed description of this type of Felton wheel is contained in the paper by the late Mr. Zodel on "High-Pressure Water-Power Works."†

FIG. 48. KINUGAWA HYDRO-ELECTRIC PLANT, JAPAN.

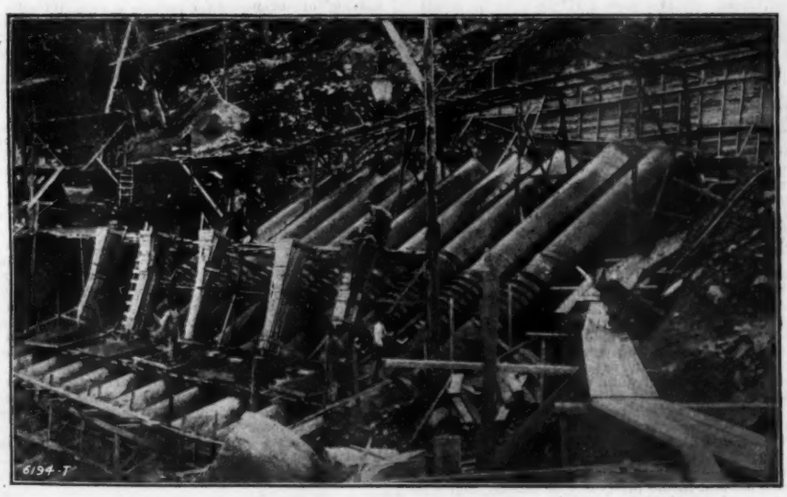


FIG. 49. ANCHORAGE FOR STEEL PIPE-LINE UNDER CONSTRUCTION.

### PIPE LINES.

The design and construction of the pipe line forms one of the most important sections in connection with a hydro-electric plant, a fact which becomes more evident when considering the great increase in falls now utilised for power purposes, and where the pipe line represents the major portion of the initial capital cost. The great stride made in the economical development of water power under high heads during recent years, and the successful harnessing of falls of over 3,000 ft., have depended to a great extent on the general progress in the design and construction of pipe lines, and the satisfactory solution of the many problems which have arisen in connection with the development of high falls. But these developments have also had an important bearing on the economic utilisation of falls of comparatively low head, as it has permitted larger diameters to be employed and consequently a smaller number of pipe lines which, in addition to a great saving in cost, by the reduction in friction losses, has contributed to the higher overall efficiency realised. Pipe lines in connection with water power installations are classified as low medium and high-pressure pipe lines.

*Low-Pressure Pipe Lines.*—The material used in the construction of low-pressure pipe lines is either concrete, riveted steel or wood. The concrete pipes are generally built *in situ*, of monolithic concrete with various systems relating to the form of reinforcement. Owing to the liability to leakage and sweating, concrete is not as a rule used under pressure, being employed in the upper portion of a pipe line where the gradient is small and where the hydraulic gradient varies from zero to about 10 ft. Under these conditions, the concrete pipe line has certain points of merit as regards initial cost and durability, and has an undoubted field of usefulness. On the other hand, the lack of flexibility and high coefficient of expansion renders it necessary to make provision to prevent cracks due to uneven settlement where the soil is of a loose nature, and also suitable expansion joints; this is often a difficult matter. In certain places, however, the concrete pipes have been made as a pressure line, when some special form of reinforcement and treatment to prevent leakage have been adopted.

FIG. 50. REINFORCED STEEL PIPE-LINE.

*Wood Stave Pipes* are utilised to a great extent for pressures up to about 175 ft. both in America and Canada where suitable wood, best-quality cedar fir, is to be found in abundance. For use in connection with water-power developments the pipe is made "continuous," the rough lumber being made into staves of correct shape and angles, and joined together on site by means of wooden or metal tongues breaking joints between adjacent staves so as to form a continuous length. The finished pipe is wound round with iron hoops and secured by adjustable clamps of malleable iron, through which the threaded ends of the rings pass and are tightened by means of washers and nuts. One of the chief characteristics of the wooden stave pipe line is its durability and low cost, together with a low coefficient of friction. It is therefore of particular advantage for the construction of the upper portion of pipe lines where suitable wood can be procured.

*Steel Pipes.*—The two types of steel pipes, riveted or welded, are used in connection with hydro-electric plants, the former for low and medium pressures, and the latter exclusively for high-pressure plants. For long pipe lines under low heads, the riveted pipe has been superseded either by concrete or wood, as for large diameter, the riveted pipe must be made sufficiently thick to retain its circular shape, and in addition take all the bending stresses caused by the weight of the water while allowing as great a distance as possible between the supports. Consequently the cost is very often prohibitive as compared with a conduit made of either of the first-mentioned materials. For instance, a 12-ft. steel pipe line requires at least ¼-in. plate thickness to fulfil these conditions, whereas, as far as the hydrostatic pressure is concerned, ¼-in. would be ample.

Recent designs of large riveted steel mains under low heads have therefore aimed at a construction which would permit of a minimum plate thickness and a maximum distance between supports. For this purpose, the pipe is stiffened by means of angle irons, designed to take up the bending moments, and the shell of the pipe itself is correspondingly reduced in thickness.

*Welded Steel* pipe lines represent the most important development in recent years as a result of the progressive utilisation of high heads which necessitated a closer study of the pipe line construction than had hitherto been the case. Moreover, the successful harnessing of falls of 1,000 ft. or more could only be accomplished by using pipe lines where the construction would offer the necessary safeguards and reliability of design required, as a failure under these conditions would have the most disastrous results. Welded pipe lines are exclusively used for high-pressure installations on account of their superior strength and absence of rivets to obstruct the flow of water and consequently reduced friction losses.

The welded pipes are made by the water-gas process,

* In view of previous remarks in reference to the increased employment of Francis turbines under high heads, it is of interest to record that for the extension of this plant it has been decided to instal Francis turbines rated at 22,500 brake horse-power per unit and operating under a fall of 800 ft., thus exceeding by more than 50 ft. the maximum fall under which Francis turbines have been installed at present.

† Proceedings, I.Mech.E., 1911, page 617.

the plates being bent to shape and the overlapping edges, Fig. 43, heated by means of water gas and welded together under high speed mechanically-driven hammers, which method produces a weld of a strength of approximately 95 per cent. to 97 per cent. of the strength of the full plate. After welding, the pipes are annealed to remove all internal stresses. The foregoing process of welding is only suitable for material up to about 1¼ in. thick, as above this thickness, the heat would not penetrate sufficiently to produce uniform welding heat. For larger plate thickness, the "wedge-welding" method is resorted to, Fig. 44, the edges being brought together and a separate bar inserted forming the weld. With this method, pipes up to a thickness of 1¾ in. can be satisfactorily welded. The material used in welded pipe lines is best Siemens-Martin steel, with a tensile strength averaging 28 tons per square inch and an elongation of 20 per cent. to 25 per cent. in a 1 8-in. test bar.

On account of the pressure rises which the pipe line may be subjected to, the plate thicknesses are calculated with a factor of safety of 4–5 : 1, based on a strength of the weld equal to 100 per cent. The individual pipes are made in lengths of an average of 18 ft. to 20 ft., using riveted joints for medium pressure and flange or expansion joints for high pressures, Figs. 45 to 47, representing the most common types of the three mentioned joints. In the riveted, or so-called "bump" joint, the pipe ends have been swelled so that the rivet heads do not obstruct the free area of the pipe.

The flange joint, Fig. 46, represents the most usual type adapted for large pipes, both ends of the pipe being turned up with loose cast steel flange rings and rubber insertion joints. In pipe lines where either of these joints are used, separate expansion joints must be provided. For this reason the high-pressure muff joint, Fig. 47, page 230, has been extensively used in connection with turbine pipe installations as each individual joint permits of expansion and separate expansion pieces are rendered unnecessary. A further advantage which is obtained by this design is, that it permits repacking the joint without displacing the pipe, in addition to greater facility in erection. Without exception, turbine pipe lines are laid above ground to enable inspection to be carried out. Each individual pipe is supported on a concrete support and heavy anchorages provided at all points where the line changes direction. In many cases, sufficient attention has not been given to this latter requirement, but the present high-pressure work demands careful consideration to this point, in fact, every detail of the pips line has to be considered in the light of the very heavy duty imposed under the high falls now employed.

Fig. 48, page 231, gives a typical example of pipe lines for a hydro-electric installation at Kinugawa, Japan. It consists of six main pipe lines with an internal diameter of 1,520 mm. to 1,100 mm. and a 700 mm. to 500 mm. diameter pipe line for the separate exciter unit. The total static head is 336 m. (1,100 ft.), and the plate thickness varies from 10 mm. at the top to 25 mm. at the bottom of the pipe, the joints used being high-pressure muff joints throughout.

An anchorage during construction at Rjukanfos, Norway, is shown in Fig. 49, consisting of 10 parallel pipe lines with a diameter of 79 in. to 50 in. undr a maximum static head of 830 ft., the thrust being transmitted to the foundation by means of a number of cast-iron rings made in halves and bolted together round the pipe. The latest improvement in the art of welding is the reinforced welded pipe, consisting of a number of solid forged rings shrunk on to the outside of the pipe adding further strength to the pipe with a reduction of plate thickness. This innovation in pipe design has been of immense importance as far as turbine installations are concerned, as for high heads it permits a larger diameter pipe being used without exceeding the maximum limit of plate thickness to obtain a reliable weld, and consequently for large installations the number of pipe lines would be less as compared with the pipes of uniform thickness, thus reducing the initial cost of installation. The first pipe line where this type of pipe was used was installed at Los Angelos, California, in connection with the Municipal Hydro-Electric power station. The inside diameter of the pipe was 80 inches with a maximum static head of 930 ft., corresponding to a plate thickness of 32 mm. The pipe was made with a thickness of 16 mm. only, reinforced by steel rings. The rings are rolled solid out of the steel billet, heated and shrunk just tight on to the pipe.

The reinforced pipe has now been adapted for several high-pressure plants, and Fig. 50 illustrates such a pipe-line in position, recently installed in Norway. For exceptionally high heads where smaller diameter pipes only are necessary, solid-drawn pipes are employed. An example is furnished by the pipe line of the Fully installation, to which reference has been previously made, as being the maximum head yet utilised, namely, 5,435 ft. The diameter varies from 600 mm. at the upper portion to 500 mm. at the bottom, with a plate thickness of from 6 mm. to 43 mm. Water-gas welded pipes are used up to 34 mm. thickness, whereas the lower portion with a thickness of from 35 mm. to 46 mm. consists of solid-drawn or pressed pipes. The present method of manufacture permits only comparatively short lengths of this diameter being made, which, however, are welded together with a circumferential weld in lengths of about 18 ft.

## CONCLUSIONS.

It will be appreciated that within the limits of this paper it has only been possible to direct attention to the main lines along which the development of this highly-specialised branch of engineering has taken place, and to indicate briefly its general effect on the utilisation of water power. In considering these developments as described in the foregoing, the outstanding features can be summarised as follows :—

1. The exclusive use of two types of turbines only, namely, Francis reaction turbines for low and medium heads and Pelton impulse wheels for high heads.

2. The extension of the use of Francis turbines under heads approaching 800 ft., and Pelton wheels in single stage up to 5,500 ft.

3. The exclusive adoption of balanced wicket gates for the regulation of Francis turbines and the circular nozzle with combined deflector and needle regulation for Pelton wheels.

4. The standardisation of turbine runners and increased specific speed permitting the use of single vertical units of large output under low heads.

5. The general increase of output per unit, the maximum output at present being 31,200 brake horse-power.

6. The general increase of the overall efficiency of about 6 per cent. to 10 per cent.

7. The exclusive use of oil-pressure governors.

8. The efficient regulation (by means of differential surge tanks) of turbines using long pipe lines.

9. The employment of large diameter pipe lines under high heads resulting in an appreciable reduction of the initial cost of development.

These developments, coupled with the improved construction of impounding dams in addition to multifarious improvements in details to ensure effective safeguards and reliability in operation, constitute as such an enormous advance from a purely technical point of view, but of even greater significance has been the unlimited field thereby opened up for the application of electricity and the extended scope given to the utilisation of water power in the service of civilisation ; issues of the greatest magnitude have been raised affecting the economic life and future prosperity of nations, and from being a question to be left solely to private enterprise, the control and development of water power now rank among the vital problems of national interest.

An attempt here even in the most casual manner to touch upon this aspect of a subject on which much could be written, would be impossible, but it is a gratifying fact to record that the development of the water-power resources has now been recognised as an important factor in the national economic problem, and in many countries Government departments have been set up to deal with this question to the best national advantage. The active interest thus shown by the respective Governments has proved to be a valuable stimulus to the development as a whole, as by its intervention the laws of water rights and their expropriation have been remodelled and amended in accordance with modern principles, and necessary safeguards provided for the protection of fishing or other vested interests in addition to the valuable services rendered in connection with hydrographical surveys and the collection of reliable data and records, in fact, in all questions affecting the rational and economic utilisation of water power.

State-owned and controlled hydro-electric power stations are now in successful operation, notably in Canada and Sweden, and it is anticipated that further important developments in this direction will take place as the war has caused attention to be concentrated on the development of the valuable water-power resources in connection with the establishing of new industries necessary to preserve independence of foreign supplies or with the object of reducing the importation of coal.

According to Professor Gibson's estimate, the tota amount of water power available in the world exceed' 200,000,000 h.p., and in Table V, below, is set out the available water power capable of economic development in the principal countries in Europe and America, together with the amount already developed, as published by the Waterpower Branch Ministry of Interior, Ottawa. This cannot fail to reveal the enormous scope for further developments of the world's water-power resources. The harnessing of distant waterfalls with the power arteries conducting the water from the mountains to the power-house in the valley below, the transmission line conveying the potential energy from the remote places to the industrial centres for useful work to the benefit of mankind, has, as already stated, been of the greatest significance to the economic development of nations, and it may be said without exaggeration, is destined to become one of the most important keystones in the industrial structure of this great Empire.

The rapids in Canada, the peaks of the Himalaya, the rugged plateaux of New Zealand and Tasmania, and the Highlands of Scotland and Wales, contain a natural wealth of incalculable value, which, together with the advances in fixation of nitrogen and other electro-chemical processes, the production of pulp, development of mineral resources and other staple industries, will in the near future prove to be a leading factor in the industrial reconstruction of our Empire, and be the means of closely linking together these great independent countries in the coming struggle for industrial supremacy.

May it be the privilege of the present generation, and in particular of the members of this Institution, to take a leading part in this great work of developing our water-power resources for future prosperity, and to safeguard the glorious traditions of the British Empire.

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TABLE V.—AVAILABLE WATER-POWER IN THE PRINCIPAL COUNTRIES OF EUROPE AND AMERICA.

| Country. | B.H.P. Available. | B.H.P. Developed. | | Area in Square Miles. | Population. | B.H.P. Available per Square Mile. | B.H.P. Developed per Square Mile. | B.H.P. *per Capita.* | |
|---|---|---|---|---|---|---|---|---|---|
| | | In B.H.P. | In Per Cent. | | | | | Available. | Developed. |
| U.S.A. .. .. | 28,100,000 | 7,000,000 | 24·9 | 2,973,890 | 98,783,300 | 9·4 | 2·35 | 0·28 | 0·071 |
| Canada A* .. | 18,803,000 | 1,735,000 | 9·2 | 2,000,000 | 8,033,500 | 9·4 | 0·87 | 2·34 | 0·216 |
| Canada B .. | 8,094,000 | 1,725,000 | 21·3 | 927,800 | 8,000,000 | 8·7 | 1·86 | 1·01 | 0·216 |
| Austria-Hungary | 6,460,000 | 566,000 | 8·8 | 261,260 | 51,173,000 | 24·8 | 2·17 | 0·13 | 0·011 |
| France .. .. | 5,587,000 | 1,100,000 | 11·6 | 207,500 | 39,601,500 | 26·8 | 3·14 | 0·14 | 0·016 |
| Norway .. .. | 5,500,000 | 1,120,000 | 20·4 | 124,130 | 2,391,780 | 44·3 | 9·02 | 2·30 | 0·468 |
| Spain .. .. | 5,000,000 | 440,000 | 8·8 | 190,401 | 19,585,700 | 26·3 | 2·31 | 0·26 | 0·022 |
| Sweden .. .. | 4,500,000 | 704,000 | 15·6 | 172,960 | 5,522,400 | 26·0 | 4·08 | 0·81 | 0·127 |
| Italy .. .. | 4,000,000 | 976,000 | 24·4 | 91,400 | 28,601,600 | 43·8 | 10·7 | 0·14 | 0·034 |
| Switzerland .. | 2,000,000 | 511,000 | 25·5 | 15,976 | 3,781,500 | 125·2 | 32·0 | 0·53 | 0·135 |
| Germany .. .. | 1,425,000 | 618,100 | 43·4 | 208,800 | 64,926,000 | 6·8 | 2·96 | 0·02 | 0·010 |
| Great Britain .. | 963,000 | 80,000 | 8·3 | 88,729 | 40,831,400 | 10·9 | 0·91 | 0·02 | 0·002 |

ESTIMATE, 1915.

* A includes Yukon and Northern Area improbable of immediate development.

VICKERS' PUBLICATIONS.—We have received Nos. 7 and 8 of *Vickers' News*, which contain the directors' New Year's greetings to their staff, articles on the steamers for Australia under construction at Barrow, on porcelain-making at the Vickers' Hanley porcelain factory, the history of Barrow, condensing and feed-heating arrangements for turbine vessels, Wolseley cars, &c. Also No. 8, of vol. v, of *The Metropolitan Vickers' Gazette*, which deals with industrial unrest, with electrical installations put down by the concern, and other matter. All three numbers are carefully printed and well illustrated.

WORKING HOURS IN GERMANY.—Reports from the different districts of Germany as regards the important question of hours of labour vary considerably. Whilst in some parts there has even been a question of extended hours, a day of 11 hours has been mentioned, the men in the Ruhr district are clamouring for the existing 8-hour day to be reduced to 6. The radical leaders of labour insist upon having the 6-hour day introduced in the new agreements, which will result from negotiations pending with regard to wages. They have a kind of basis for their demand in the report drawn up by the Commission which was appointed some time ago to examine into the conditions of labour in the mining industry, and which report favours their demands. On the other hand, both the Government and the employers are decidedly against this reduction of hours, and a number of workmen in other industries also strongly oppose the Ruhr district demand. In the mining industry also many men are against the reduction, and the Christian Workmen's Trade Union denounces it. A further decrease in the production of coal will very seriously affect a number of industries, of which many already suffer from a shortage of fuel.

A FATAL LABORATORY ACCIDENT.—A fatal, and unfortunately unexplained accident occurred last November in the Chemistry Division of the United States Bureau of Standards at Washington. Mr. E. McKelvey, chief of the physical chemistry section, was engaged with two other members of the staff in determining the freezing-point of ammonia. The apparatus was contained in an unsilvered Dewar flask, a cylinder 20 cm. high and 9 cm. wide. Within the flask was mounted a glass tube containing the ammonia, a platinum resistance thermometer, a stirrer driven by an electric motor about a foot away, and a copper coil into which liquid air was siphoned at the rate of about 1 cub. cm. at a time. The liquid in the flask was petroleum ether, previously cooled to 0 deg. C., to serve as liquid bath for the glass tube. The apparatus had already been used several times. Mr. McKelvey was temporarily alone, siphoning in liquid air when, 20 seconds after his colleagues had gone to the adjoining room, an explosion was heard, and McKelvey appeared in the door, covered with flames. The shower bath in the doorway was at once turned on, and it is said that the flames were extinguished within 5 seconds ; yet McKelvey succumbed on the following day. The Chemical Society of Washington, investigating the accident, suggests that either the Dewar flask collapsed causing a spark or spilling the petroleum ether, or that some static spark ignited the ether, or that the ether vapours first caught fire at the commutator of the motor. If the precaution of the shower bath were necessary it would appear to be very unwise to use so dangerous a liquid as petroleum ether close to an electric motor.